SCIENTIFIC AMERICAN

No. SUPPLEMENT, 852

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Scientific American Supplement, Vol. XXXIII. No. 852. Scientific American, established 1845. NEW YORK, APRIL 30, 1892. Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.

THE GROTTOES OF MESCHERS.

THESE grottoes, united within a space of half a mile at the most, spread out under Meschers, a borough of Charente-Inferieure, situated upon the right bank of the Gironde, at six miles to the southeast of Royan.

The village is reached from Royan through a Decauville car which stops at Saint Georges, a third of the distance. The four miles remaining succeed each other through a fertile country, and the road, which is somewhat uneven, extends in great part under pines and Italian poplars. Meschers, which is perceived beneath the road, is in reality situated at some sixty feet above the level of the Gironde. To the right, five windmills, some of which no longer have any sails, are aligned upon the bank and dominate a high cliff that one would not at first suspect. They indicate to him who wishes to follow us in this trip the location of the grottoes. From their base we see the river in all its breadth with its yellowish waves mingled with sea water. Its majestic extent is limited only by the horizon of the sea on the west, and the famous tower of Cordouan watches in the offing the steamers arriving from all parts of the world and on their way to Bordeaux. The cliff, which is eighty feet in height, is perpendicular with the mills, for on this bank the strongest currents prevail. The bank is gradually being worn away, and it may be foreseen that the mills will fall into the depths of the river along with the grottoes located under their foundations. But at this epoch they will long since have ceased to grind their last grain of corn. The rock is composed solely of more or less compressed fossil shells. It is in this formation that the grottoes have been hollowed out, half by nature and half by the hand of man. From the top of the cliff one would not guess their existence. In order to visit them, let us take one of those numerous goat paths which descend from the mills and disappear almost instantly in the superposed steps forming the high wall.

Women, and especially children, will do well not to venture alone into these winding paths on the side of the cliff. In many places it has been necessary to excavate the rock in order to get a foothold, and the sides of these paths are covered with dry and slippery herbs. All the grottoes are not so difficult to reach; but *per contra*, certain paths leading only to the stations of shrimp fishermen terminate in a pole with rounds, in lieu of a ladder, for descending to the edge of the water.

Toward a third of the height of the cliff, the pathway followed invariably meets with some excavation that might be taken for the nest of a gigantic sea bird contemporary with the first strata of the fossil shells in which these holes are excavated. Yet one soon remarks that the floors and ceilings of the grottoes have been rendered even by the hand of man. The wide opening alone, giving a view of the sea, has been rendered jagged by the southwest winds and rains. Most of these cavities were still inhabited up to fifty years ago, but the downfall of the rock, progress, etc., has caused them to be abandoned. Three only still remain occupied, and those who dwell therein are willing to say that they get along very well, being warm in winter from exposure to the south, and completely sheltered from the north. These grottoes are in nowise damp, as might be thought, and the rent costs only the small sum imposed by the owner of the roof, that is to say, of the land above the excavation.

On the side toward the sea the natural opening is closed by boards or dry stones. One or two small windows give sufficient light. Usually, the habitation consists of two apartments separated by a partition formed during the excavation of the grotto. A stock of furniture as comfortable as that of many peasants completes the installation. Outside, other excavations, not so deep, are used for the storage of a few spare fagots designed for cooking, in an earthen pot, a soup made of fish and of Portuguese oysters, collected in abundance at the foot of the cliff. Moreover, some fishermen have converted certain cavities difficult of access into receptacles for their apparatus for shrimp fishing. From these they drop their small lines baited with the remains of crabs, the best bait for this kind of fishing.

The visitor who traverses all these cavities, placed one above another, experiences a quasi-deception on visiting those still inhabited. He expects to find therein the last expression of poverty without an asylum, and he sees naught but people who are as well satisfied as was Diogenes in his tub.

Let us make a call on these philosophers before the last of the present occupants have been driven out of the grottoes by a threatened caving in. After reaching the windmill to the west and walking a distance of about fifty yards toward the mouth of the river, on the edge of the cliff, we descend by a winding pathway to the "Femme Neuve" (Fig. 2), so called be-

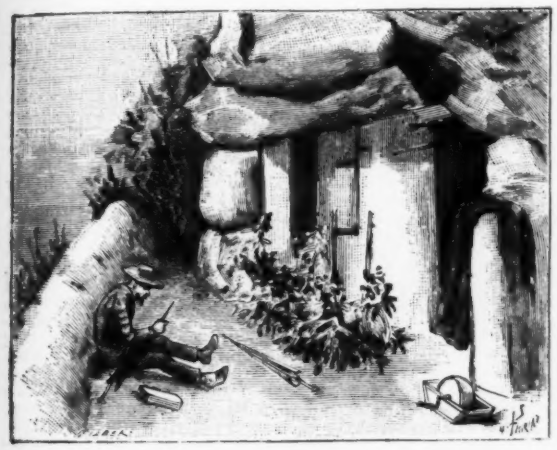


FIG. 1.—THE KNIFE GRINDER'S GROTTO AT MESCHERS.

FIG. 3.—INTERIOR OF THE GROTTO OF "FEMME NEUVE."

FIG. 2.—ENTRANCE TO THE GROTTO OF "FEMME NEUVE."

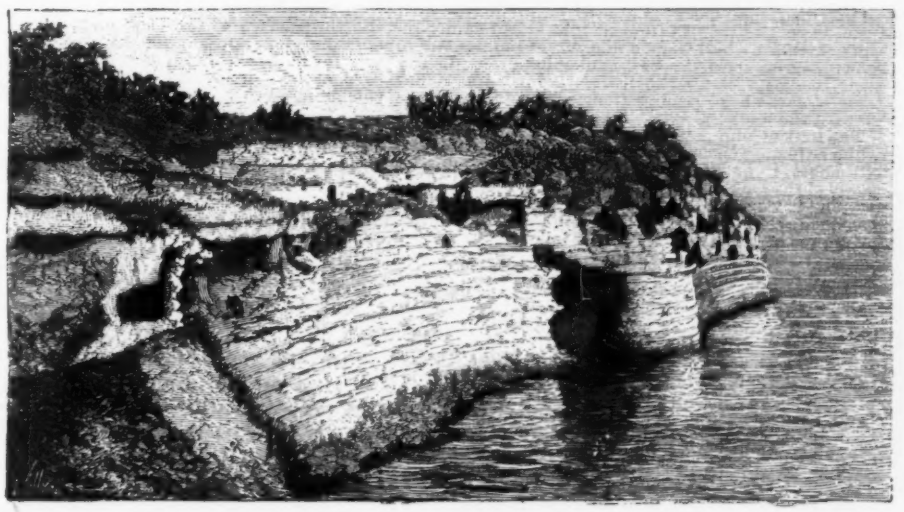


FIG. 4.—THE GROTTOES OF MESCHERS, IN THE CLIFF.

cause it is relatively new in the country. The tourist is heartily welcomed by the inhabitant of the grotto, and the small sum received from him, added to a small trade in vegetables, afford her an almost easy existence. Her young girl does her best to help her. When we enter, the two troglodytes are about scalding the linen to be washed (Fig. 3), the steam escaping without trouble through the boards that serve as a wall upon the sea. Alongside, a second cavity is converted into a bed room, in which we see two beds, a chest of drawers supporting a few cheap objects, and, opposite the beds, a chimney with its back toward the sea, between two small glazed windows (Fig. 5).

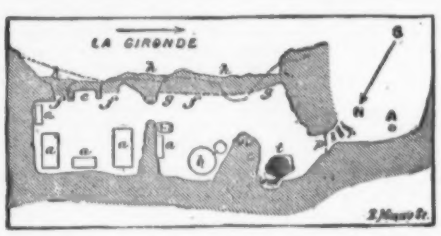


FIG. 5.—PLAN OF THE GROTTO OF "FEMME NEUVE."

a, beds and closets; *b*, lye tub; *c*, chimney; *f*, window; *g*, vertical boards; *h*, edge of the rocks 65 ft. above the sea; *p*, door; *r*, steps rising to the top of the cliff.

During the high winds from the southwest the spray rises to these heights, the tempest projects the water against the board front, which gives way under the stress, and the inundation of the interior renders the two chambers uninhabitable. It is even impossible to descend the foot path which runs from the summit of the cliff to the door. It is then necessary to go to seek a lodging in some barn of the village. Thus, last winter, it became necessary for the inhabitants to desert the cavities for three consecutive days. The foot-path between the first two mills to the west leads to the second grotto. This gives shelter to Father Lavigne, an old man about eighty years of age, who still makes his weekly rounds at Royan, and at night re-enters his abode, his step light and his pocket heavier by a few penny pieces. Like all the people of the country, he is hospitable and polite. He received us hat in hand and led us to his two very bare chambers, the furthermost of which gives a magnificent view of the abyss and the sea. Father Lavigne's furniture is simple and very neat, and this isolated old man without family, who has lived here for more than forty years, declares that he is quite happy, for his health remains to him. His stay in the grotto has never inflicted upon him those rheumatic pains that are so frequent with men of his age and in his condition.

Finally, the last interesting grotto is situated to the east of all the mills. The path leading to it begins at about 150 yards from the mill most distant from the mouth of the river. A locksmith and knife grinder has recently established himself in this cavity, for which he has the love of a hermit (Fig. 1).

The door and window are open; a poor straw bed upon four stakes, a table, a few utensils and a chair form the whole furniture of this single chamber. In one corner, a grindstone and a smith's forge in the course of construction show by their arrangement that an ingenious man has been able to get up all this with primitive materials. In front of this bright sunny retreat extends a small terrace that serves the troglodyte as a hanging garden. Beautiful gillyflowers display their blossoms under the little window, and a few tomato plants are ripening their red fruit under the glare of the hot sun.

The lord of the manor narrated his history to us while adjusting the external flue of his forge with some old sheet iron. He was born in Angouleme and traveled through France and England, going at random and working here and there. The lucrative journey work of the large workshops kept him for some time at Paris, Saint Nazaire, etc. After having wandered voluntarily, he now, at the age of about forty years, is eager only for rest. The embellishments of his home are his dominant preoccupation, and he shows them to his visitors with enthusiasm. He is to plant some white gillyflowers under the fossils that overhang the window. "It is the only variety," says he, "that is capable of withstanding the wind of the sea. I have found it here and at Quimper only. Next year I shall set up a trellis near my door, but shall not permit it to extend the vines to more than a yard, for the salt air that burns the corner of this rock would mercilessly parch it. And then I shall set up a little straw tent upon my terrace; you see that the sun gives us a little too much heat in summer. It is true that I shall never have need of fire in winter. Work in the village suffices for my needs. I make small repairs of household utensils. I have need of nothing more for enjoying in tranquillity the rest that I have found at last."

Could it be that happiness has found its nest under these venerable strata of accumulated fossils? Has this itinerant knife grinder been able to seize it after so many travels through Europe?

Other grottoes, acquired by well-to-do persons, have been modified from top to bottom, partitioned off, furnished, and (oh! horrors!) hung with flowered wall paper. These are small bourgeois observatories, a visit to which is not without interest. Then at the very base of the cliff of the east side there exist large regular cavities which some of the inhabitants regard as having been the refuge of the Protestants during the wars of religion; but, in reality, after that epoch at least, they became quarries which yielded a beautiful soft stone that consisted of a layer of shells reduced to powder through the pressure above. We may still see the place where the lighters came alongside of the entrance of the quarries, and the oldest inhabitants of the county remember their exploitation.

As for the fossils, although their number is infinite, the collector will need an experienced eye to gather the most interesting. Rare species of sea urchins and bivalves of all sorts are found here intact, and, if one desires to obtain an idea of their varieties, he must visit the Paleontological Museum of Meschers. Here in a room filled with all the fossils of the region, a modest and venerable savant, Mr. Gagneux, will welcome you cheerfully and will be very glad to see his collections appreciated at their value. He obtains but small profit therefrom, as his fossils are too little known; but this learned collector is an artist, an enthusiast for whom eating and sleeping are not worth the incomparable find of a beautiful specimen of *Radiolites Semani* or *Siphosum magnificum*.—*La Nature.*

FLORIDA PHOSPHATES; THE ORIGIN OF THE BOWLDER PHOSPHATES OF THE WITHLACOOCHEE RIVER DISTRICT.*

By Prof. N. A. PRATT.

I HAVE studied with much care the geology of the phosphate region, extending along both sides of the Withlacoochee River, at intervals, for a distance of 60 miles north and south and 15 miles east and west, to ascertain, if possible, the conditions under which the deposits grew and accumulated, and the law of its relation to the rocks that underlie and surround it. The task is difficult and one that required close inspection of details, over a larger area than the time allowed and the limits of this property permitted. The material is new to the world, the detailed geology of the State practically unknown; its topography yet to be ascertained. No facts are available on which to base even a theory, except those discovered by my own limited observation. Still I believe I have ascertained and established the true origin of the material, and as soon as the topography and levels are known I will be able, with some degree of assurance, to predicate the possibilities of finding, or not finding, the material in any given locality, with a reasonably close approximate estimate of the quantity, and thus lay the foundation for successful mining.

We have now to consider what is the original formation and origin of these deposits, and what its causes? The prevailing impression that the phosphate deposits are "pockety" and found only in limited and uncertain areas, and that they extend downward to unknown depths, is not tenable, as will appear below. Several opinions and theories as to their origin have been expressed and published, among which I may refer to a few from memory:

(1) That of a pure bird deposit in localities favorable to the roosting of water fowl more nearly covers the conditions of the problem as presented in one locality examined by me than any heretofore advanced, but the evidences are all opposed to that theory in the case of the Withlacoochee River deposits and cannot be entertained here, for certainly this form of calcium phosphate has never existed in vertebral bone, which is the basis of all phosphatic bird deposits.

(2) That the underlying lime rock contains a certain percentage of lime phosphate (say 5 per cent.) as an integral part of its composition, and that the lime carbonate being dissolved and carried off by carbonated soil or swamp waters percolating through large areas, there was left the 5 per cent. of the insoluble lime phosphate, and this was subsequently, by natural causes, consolidated into bowlders, nodules, or plates; that is to say, that for every 5 feet or inches of deposit, 100 feet or inches of lime rock has been dissolved and carried away. This idea is plausible, but its importance is overestimated, for the underlying and even associated lime rock nowhere shows more than 1 per cent. of bone phosphate, and seldom so much.

(3) Directly opposed to this, it is held by some that the top surface of the lime rock, constantly bathed with phosphates in solution, has exchanged its carbonic acid for phosphoric acid, and thus metamorphosed its carbonate of lime into phosphate of lime, "just as shell or coral rock is silicified into buhrstone, an almost pure sand rock or flint," which is a very unfortunate illustration. This theory is more untenable than any advanced. The evidence of the material disproves it, for in every case in which shell impressions occur, a cavity appears indicating the space formerly occupied by the calcareous shell, which has disappeared entirely, leaving only its impression or cast in the phosphatic material. In no case have I ever seen a calcareous shell transformed into a phosphatic shell. The phosphates in the Withlacoochee district have few or no shells or even impressions thereof.

My own impression, based on evidences collected there, is that the whole deposit, in all its varied form, had its immediate origin in animal life and agency, and that the phosphate bowlder is *a true fossil or fragments thereof*. The animal, if such, extracting lime phosphate either directly from the mineral world (viz., the waters of the sea, as plants do), or more likely by feeding on lower vegetable organisms that abound therein, and secreting the same phosphate of lime as its own solid skeleton to support its own gelatinous body, thus maintaining the accepted law of nature that no *mineral* matter can be assimilated and raised to the higher plane of *animal* life and structure without having previously passed through the lower plane of *vegetable* life and structure. In this case, however, the animals (if such) were of the lowest types, and so closely allied to the lowest types of plant growth that naturalists have scarcely yet agreed as to their affinities.

In this connection it is immaterial how their food was obtained, as the result is the same. Some kinds of sponges, infusoria, zoophytes and animals of the lowest type assimilate directly from the water, or from their food, and secrete silica (flint), some lime carbonate, and some a horny substance, as their supporting skeleton, and this secretion and growth continue until the favorable environments change, the animal is exterminated, and a massive nodule of flint, a stratum of infusorial casts or tripoli (silica), a cliff of chalk or a coral reef remains as the result of their life work. Is it at all improbable that other species may have secreted a skeleton of *lime phosphate*?

Most shells either recent (living) or fossil consist mainly of the lime carbonate secreted by the animal; some, however, are known to secrete and live in a shell of lime phosphate. To-day, on the coast of North Carolina, is a mollusk, the lingula, living and flourishing in a shell containing 50·34 per cent. of *lime phosphate*, and 43·33 per cent. organic matter, the same as fresh human bone, and when deprived of its organic matter the bone phosphate is 85·81 per cent., the same as the fossil shell contains. This fact was discovered only a few years ago (1869), when attempting to trace and discover the origin of the phosphates of South Carolina, and wherever the fossil of lingula is found, even in oldest Silurian times, the shell is *lime phosphate*, 85 per cent. Several other fossil shells, closely related to the lingula and of the same geological age, have approximately the same composition. If the lynx-eyed miner, manufacturer or merchant fails to recognize at sight a valuable commercial article, can the naturalist, who is seldom a chemist, be blamed for considering a phosphatic skeleton a calcareous one? It is no stretch of the imagination to assume that some of the lower types of animals, such as sponges, zoophytes (protozoa), rhizopods, foraminifera, etc., had the power and exercised it, in building up a skeleton of lime or *bone phosphate* for the support of their turgid and gelatinous bodies.

I have before me many samples of so-called phosphate bowlders, from the size of a match box to five and eight feet in diameter. The most perfect shows a complete spiral or circular band or sheet around a central axis or stalk almost as symmetrical in arrangement of its loosely separated concentric laminations as the encircling leaves of a head of lettuce, which it closely resembles in appearance, except that the laminations are continuous in concentric or spiral bands. I am satisfied that the phosphate bowlder of Florida is the fossil remains of a gigantic foraminifera; perhaps as considered by some naturalists a sponge-like coral, having in every part of its skeleton identical composition (but not structure) with bone deprived of its organic matter. I am constrained to believe that such a structure can only be attributed to life agency, and under no stretch of chemical or physical law can such be called a concretion or conglomerate or be formed and shaped by any other power than that of life agency and organized growth.

I am led to this lengthy explanation in order to say that the evidences compel me to believe that all of the phosphate bowlders in the ledges or surfaces exposed, and classed as laminated and conchoidal types, grew as a zoophyte, possibly as a sponge, more probably gigantic foraminifera or rhizopod on the spot in which it is now found, just as sponges now grow in favored localities and as oysters of gigantic size, found in the Tertiary age, grew and flourished under favorable conditions, and left their shells even 16 in. to 20 in. long still attached to the bank on which they had thriven so well. I will not attempt in this article to reason out the origin of each of the other types of Florida phosphates further than to say that the types Wedgewood and Oreole (soft phosphate) show to the unassisted eye no indication of organic or of organized structure. *Such I have no doubt the microscope will reveal.* It is certain, however, that they have a close relation to the bowlders of "hard rock," described above, since the material is in, around, and under the bowlder masses, and is generally bedded in sand or clay.

Accepting as true that we are dealing with gigantic foraminifera or rhizopod (which propagate themselves by "division" or "budding"), it is not unreasonable to suggest that the soft white material may be made up of the remains of (for want of better name) the "germ spores" and "buds" (spawn) of these prolific animals—possibly the comminuted debris of the gelatinous animals themselves, just as soft calcareous marl is the debris of the coral reefs, that grow and accumulate in practically the same manner. It is probable that the delicate gelatinous flesh (sarcode) of these lowest types of animals provided abundant food for higher types, in which case the excrement of these marine animals (but not of birds) would consist largely of the comminuted debris of the phosphate skeleton of the food taken.

A remarkable fact, seen at many of the mines, adds evidence to the strength of my theory as to the organic origin of the material. It is well known that most rock formations, clays and sands are colored more or less reddish with ferric oxide, and that wherever these are brought into intimate contact with organic matter (such as the "flesh" (sarcode) of these gelatinous animals would afford) undergoing decomposition, the red ferric oxide is reduced to a soluble form and is readily leached out of the sands and clays, leaving them white and free from all tinge of color. No doubt this same reaction has bleached the phosphate beds and also the associated sands and clays to the most dazzling whiteness that is so often seen at the mines, in strong contrast to the dirty reddish color of the overlying sands. But the most convincing argument lies in the absolute horizontality of the hard rock or bowlder, phosphate zone or belt, when referred to tide water level (being never lower than 25 ft., nor higher than 100 ft. above tide), indicating as it does that during one of the periods of the oscillations of the peninsula, probably near the end of the Middle Eocene epoch, the phosphatic producing animals commenced their growth simultaneously all along the Gulf coast, extending at least 150 miles south of what is now the Georgia State line, within the limits of the depth of water and under other conditions best suited to their development, and continued to flourish and grow so long as favorable environments, chiefly the proper depth of water, existed. The affinities of the fossil are with *Strematapora* and the growth probably was in deep water. On the elevation of the land and subsequent emergence of the peninsula, this bank or bed, lifted out of the sea, remains as the life work of these animals and the depository of this accumulated wealth, and is confined apparently to a zone or belt from 60 ft. to 65 ft. in altitude or thickness. A practical inference from this is that under most favorable conditions some of the ledges or banks of bowlder phosphate, to wit, those found at highest elevation, may extend to a depth of 60 ft. to 65 ft. before striking the lime rock, beyond which point it is needless to search. The underlying and associated lime rock is a true nummulitic and orbitoides-limestone, generally considered the Vicksburg, conventionally referred to the Upper Eocene period, but to me the formation seems to belong to the Middle Eocene.

* *Eng. and Min. Jour.* The opinions embodied in this article were originally expressed in a professional report written in April, 1890.—N. A. P.

I have been in doubt until recently whether or not the phosphate deposit was of the same age as this lime rock and the accompanying sand rock and cherty flints. Of this I am now assured, having found identical fossils in both. It was my impression that the sand rock, generally a gray and porous mass at the surface, but flinty at the center (and which I have seen in long ledges standing 5 ft. to 10 ft. above the surface and evidently the product of sponge growth), is older than the phosphate growth, and underlies it. Possibly they grew and flourished simultaneously, each in the locality and environment that best suited it. In any case the latter outlived the former, and perhaps, under the law of the "survival of the fittest," overpowered and exterminated it, and it follows that the phosphates may reasonably be looked for alongside of the flinty type of sand rock, but will not be found among the underlying lime rock except where it has subsided into a lime sink or like depression.

THE PUMA, OR AMERICAN LION.*

THE puma is the only large, unspotted, native American cat. The general color of the fur is tawny, but on the under surfaces of the body it is whitish. The color of the central line of the back is darker than that of the sides and the end of the tail is dusky brown. The ears are black externally, with a central whitish area. The upper lip is white from the nostrils to the middle of the mouth, and at the latter point is a prominent black spot. The nostrils are flesh colored. Baird compares the color of the puma to that of the Virginia deer, and states that it varies with the seasons as it does in the deer; that is, the summer coat is reddish and the winter coat grayish.

There is much variation in color among individuals of this species, but it has not been proved that this is correlated with the varying climatic conditions of its range. The occurrence of albino pumas in the Alleghany Mountains and in New Mexico has been reported, but not authoritatively.

Burmeister remarks on this point: "Very rarely individuals of this species of a brown, nearly black color have been found, while differences in color between yellowish brown and yellowish gray are not rare. I am aware that individuals nearly white and others nearly black have been observed, but I have never seen such myself."

New-born pumas are very different in appearance from the adults. Instead of being of uniform color, the back and legs are covered with large blackish-brown spots, and the tail is ringed with the same color. According to Dr. W. A. Conklin, these markings disappear in about six months after birth.

The male puma in the National Museum is of the following dimensions: Head and body, measured along the curves, 53 in.; tail, 26¼ in.; height at the shoulder, 22½ in.

Audubon and Bachman give the following dimensions of a male killed by J. W. Audubon at Castroville, Texas, January 28, 1846: From point of nose to root of tail (whether measured along curves, not stated), 5 ft. 1 in.; tail, 3 ft. 1 in.; height of ear posteriorly, 3 in.

The male puma measured by Azara was somewhat smaller, the head and body being 51½ in. and the tail 29 in. The system of measurement is not given.

The average dimensions obtained from these three individuals are: For the head and body, 55 7/11 in., and for the tail, 30¼ in.; total, 85 in.

I have found no authentic record of any individuals measured before skinning of which the dimensions were greater than those of Audubon's specimen mentioned above. The total length in that case was 8 ft. 2 in. There are, however, records of measurements of flat skins of greater size. I have myself measured a skin from Colorado in the National Museum, No. 19,906, of which the total length in a straight line is 8 ft. 4 in.

Mr. Livingston Stone states that the skin of a puma killed on the McCloud River, California, "measured 8¼ ft. when stretched." The average total length of nine flat skins of adults in the possession of Mr. F. S. Webster, of Washington, is 7 ft. 4 in.

The area over which the puma ranges extends from New England and British Columbia to the Straits of Magellan. On the Atlantic coast of North America the species has apparently not been found in the States of New Hampshire, Rhode Island, New Jersey, or Delaware. On our northern boundary I find no mention of its having been found in Michigan or Indiana. In Ohio it was extirpated prior to 1838, and probably more recently in Illinois and Indiana. I find no record of its occurrence in Nevada, but as it has been found in the surrounding States it seems improbable that it should be entirely absent there.

With these exceptions there are recorded instances, more or less numerous, of the occurrence of the puma in every State and Territory of the Union, dating from the beginning of the century. Like many other large American animals, however, the puma has retired before the advance of civilization, and in many of the more thickly populated States it is improbable that even stragglers could be found at the present day.

The puma occurs throughout Central America and in all parts of South America to the Straits of Magellan.

The first mention of the puma appears to be the remark in the letter of Columbus regarding his fourth voyage in 1502. In the narrative of his exploration of the coast of Honduras and Nicaragua he writes: "I saw some very large fowls, the feathers of which resemble wool, lions [*leones*], stags, fallow deer, and birds."

There are also references to the occurrence of the puma in North America of very early date in the narratives of Laudonniere, Hariot, Coronado, Hawkins, and others.

The puma, regarded as a species, possesses in a remarkable degree the power of adapting himself to varied surroundings. He endures severe cold in the winter in the Adirondack Mountains and other parts of our Northern frontier, and tracks his prey in the snow. He is equally at home in the hot swamps and canebrakes along the river courses of our Southern States.

In South America he inhabits the treeless, grass-covered pampas as well as the forests. In the Rocky Mountains, as I am informed by Mr. William T. Hornaday, he ascends to the high altitudes in which the mountain sheep are found. Mr. Livingston Stone saw tracks of the puma on the summit of Mount Persephone in California, at an elevation of 3,000 ft. Similarly, Darwin states that he saw the footprints of the puma on the cordillera of central Chile, at an elevation of at least 10,000 ft.

According to Tschudi, the puma is found in Peru in the highest forests and even to the snow line (though seldom here). A writer in the "Encyclopædia Britannica" states that "in Central America it is still common in the dense forests which clothe mountain ranges as high as 8,000 or 9,000 ft. above the sea level."

In these different regions the puma always selects for his abode such spots as afford some shelter, but we find him in the thickets and copses, rather than in the great forests.

"Those panthers that we have observed," writes one of the naturalists of the Mexican Boundary Survey, "were always found in the most solitary places, generally where there were thick bushes, and in the vicinity of rocky spots, affording caverns for secure concealment, and in which to bring forth their young."

The puma seeks his prey chiefly at dawn and twilight and under cover of night, but he also sometimes hunts by day. The different species of American deer are his principal quarry, but he preys also upon smaller mammals. He will even feed upon the different species of American porcupines, despite their quills, which lacerate his mouth and face. Audubon and Bachman state that raccoons and skunks, as well as birds, form a part of his food, and that he will eat carrion when hard pressed by hunger. To this list Brehm adds the South American coati, agouti, and paca, and the rhea, or American ostrich.

Dr. Coues and Yarrow state that in New Mexico and Arizona the puma kills hundreds of wild turkeys and has indeed broken up many of the former breeding places. Pennant asserts that the wolf serves the puma for prey. This is improbable. Nevertheless, he reports that there was in the Museum of the Royal Society of London the skin of a puma which was shot shortly after it had killed a wolf.

Of the larger domestic animals, such as the horse and cow, the puma attacks only the young, but he will carry off a full-grown sheep from the fold, and not unfrequently preys upon the llama in South America.

In the less settled portions of America the puma has proved at times a great hinderance to stock raising. Kennerly states that in Sonora, Mexico, it kills many colts and calves, and is poisoned with strychnine by the herdsmen. Mr. C. H. Townsend remarks, in 1887: "It is practically impossible to raise colts in the Shasta County hills, California, on account of these pests. They destroy many hogs and young cattle also, but do not present so serious an impediment to the keeping of these animals as in the case of horses." I have recently received similar reports from other sources.

The puma does not ordinarily attack men, but, on the contrary, when surprised attempts to flee from them. Nevertheless it seems probable that some individuals, when strongly pressed by hunger, or moved by other unusual circumstances, may be emboldened to make such attacks. Hensel affirms that such is the case. Darwin states that he had heard of two men and a woman who were killed by pumas in Chile. McMurtrie mentions that a woman was killed by a puma in Pennsylvania, January, 1830.

That the puma sometimes kills the hunter who has wounded him is doubtless true, as any wounded animal is likely to turn upon its persecutor, but this is quite different from an unprovoked assault.

It is the habit of the puma to spring upon his prey from an eminence, such as a ledge of rock or a slight rise of ground. If he fails to strike his victim, he seldom pursues it for any considerable distance. In northern regions, however, he sometimes pursues the deer when they are almost helpless in the deep snow. It was reported to Darwin that the puma killed its prey by jumping upon the shoulder and turning the head back with its paw until the vertebræ of the neck are broken or dislocated. Azara ascribes the same habit to the jaguar.

The female brings forth her young in some secluded spot. In the Adirondacks, according to Dr. Merriam, "the lair is usually in a shallow cavern on the face of some inaccessible cliff or ledge of rocks."

"In the Southern States," says Audubon, "where there are no caves or rocks, the lair of the cougar is generally in a very dense thicket or in a cane brake. It is a rude sort of bed of sticks, weeds, leaves, and grasses or mosses, and where the canes arch over it, as they are evergreen, their long pointed leaves turn the rain at all seasons of the year.

From two to five young are born at a time. Bartlett states that in captivity the number is usually two, but sometimes one. Their young are reared without difficulty. They are brought forth at the close of winter or early in spring in the northern parts of the United States, and at the beginning of summer in South America, that is at the end of December. The period of gestation is from thirteen to fourteen weeks. The young first open their eyes when nine or ten days old. Their total length when born is from 10 to 12 in. Dr. Merriam is of the opinion that in the Adirondacks the puma does not breed oftener than once in two years.

The age which the puma attains in the state of nature is unknown. It may be remarked, however, that one lived in the Zoological Garden at Frankfort, Germany, sixteen years, one month, and nine days. It died from injuries received by accident, October 13, 1878. Dr. W. A. Conklin states that the various species of cats live in captivity fifteen or sixteen years, but show signs of decay at twelve years.

Authoritative writers upon the habits of the puma in North America agree that the adults do not commonly or frequently make use of trees except when traversing precipitous cliffs or when pursued by dogs. Under the latter circumstances they do not climb into a tree, but jump upon the nearest branch, even though it be at a considerable distance from the ground. Rengger, in his "Travels in Paraguay," however, states that both the puma and the ocelot climb well, and that in the forest they make their flight not only on the ground, but also by springing from tree to tree. He tells us in another place that he once saw a puma chase a troop of monkeys through the forest by jumping from bough to bough among the trees. However incredible this may at first appear, it becomes less so when we consider the wonderful denseness of the South American forests, described by Humboldt and other writers.

The puma, like the cat, has the habit of scratching the bark of trees with its claws, for the purpose of sharpening or smoothing them. Having mentioned this habit as possessed by the jaguar, Darwin writes: "Some such habit must also be common to the puma, for on the bare, hard soil of Patagonia I have frequently seen scores so deep that no other animal could have made them."

Many reliable authorities are agreed that the puma does not ordinarily emit loud cries or screams, but Kennerly, one of the naturalists of the Mexican Boundary Survey, states that on one or two occasions the cry of the puma was heard at a distance, and Schott writes as follows:

"After dark his mournful note is heard resounding through the solitudes of the deserts. The note, listened to once attentively, is apt to make a deep, lasting impression. The different native names, as pronounced in Spanish, sound very appropriately to the note, and it is likely that the cry of the animal forms the base of its names. The note itself is often several times repeated, with intervals of from two to four minutes. As night advances the cry is heard but rarely." He also writes: "A puma was killed on the Rio Bravo, between Fort Duncan and Laredo. During his struggle with the hunters and dogs he raised a terrible cry, twice or thrice, to express his rage, and perhaps also to give his family the notice of danger."

Dr. J. A. Allen reports that he once heard the puma's cry near his camp in Montgomery, Colorado. Eliot likewise states that he heard the cry of the puma at night, while camping on the St. John's River, Florida. He did not, however, see the animal. Darwin states that the puma does not often utter cries. He writes: "It is a very silent animal, uttering no cry, even when wounded, and only rarely during the breeding season."

In captivity the puma purrs when pleased, after the manner of the cat, and the female has been heard to utter a mewing sound.

The flesh of the puma is eaten by certain of the South American Indians, and was likewise eaten by the natives of North America, according to Catesby. Darwin, who tasted it himself, states that it is white in color and has the flavor of veal. Numerous other explorers and travelers make the same comment. Azara says on this point: "I have known my peons to eat it in preference to beef, even when that meat was to be had in abundance."

The puma is known under a multiplicity of English names. Among these are panther, painter, cougar, catamount, wild cat, American lion, California lion, silver lion, mountain lion and tiger.

The word *puma* is the native Peruvian name, according to Garcilasso de la Vega, La Condamine, Tschudi, and other authors.

Cougar is an English form of the word *couguar*, which Buffon derived by abbreviation from *cuguacu ara*. This latter word, lengthened to *cuguacuarana*, is, according to Markgrave, the native Brazilian name. Azara, however, states that the ancient name, used by the Guarani Indians of Paraguay, was *guazuara*. Others called it yagua-Pita, meaning red yagua, or *yaguati*, meaning white yagua.

The word "painter" is a corruption of panther. It is unfortunate that this latter name has gained general acceptance in the United States, since the true panther is a spotted, Old World cat, very different in appearance from the puma.

The name mountain lion is not altogether inappropriate, as the puma somewhat resembles the female lion in color and general form. From the earliest days the puma has been called the lion (*Leon*) by Spanish Americans, and the name is still used.

The names catamount, or catamountain, and wild cat have no special applicability to the puma. They have been used by English writers to designate the European wild cat (*Felis catus*) and lynxes, and by Americans have been applied to the lynxes of this country.

Besides those names which are in common use, there are some which have been invented from time to time by various authors, and are known to zoologists as "book names." Buffon's name *cougar* really belongs to this class, as do also the names Brazilian cat (*die brasilianische Katze* of Muller), the brown tiger of Pennant, and the red tiger (*Tigre Rouge* of Barrere).

As already stated, the puma is called the lion (*Leon*) by Spanish-Americans, while the jaguar is styled the tiger (*Tigre*). Early Spanish writers, however, did not always distinguish between the two, and sometimes mentioned the puma under the name of tiger, or used the name in some modified form, as red tiger, etc. Molina states that it is called *pagi* in Chile, and according to Clavigero it was known to the Mexicans as *mitzli*.

The puma is the *Felis concolor* of Linnæus. This name has been adopted by subsequent authors, almost without exception. Schreber, however, has two figures of the species in his work on mammals, one of which is styled *Felis discolor*.

Molina, in 1782, gave it the name of *Felis puma*, and Lesson that of *Felis unicolor*.

FREDERICK W. TRUE.

* Abstract of a paper in the latest Report of the National Museum.—*Science*.

THE HORSETAILED SQUIRREL IN THE DRESDEN ZOOLOGICAL GARDEN.

THE traveler, Mr. Otto Herz, of Blasewitz, near Dresden, was commissioned by the Russian Grand Duke Nikalai Mochailowitschm to pass the years 1883 to 1886 in Japan, Corea, Northern China, the island of Hainan and Siam, for the purpose of studying natural history. When he returned he brought to the Dresden Zoological Garden a very rare squirrel, from the island of Hainan, different from any that had ever been exhibited in Europe before, and a droll, tame orang-outang from the province of Sarawak. The latter succumbed immediately to the climate, but the large and beautiful rodent kept perfectly well, and furnished great amusement to all who visited the birds' house, where he was placed temporarily, by his bright and funny ways.

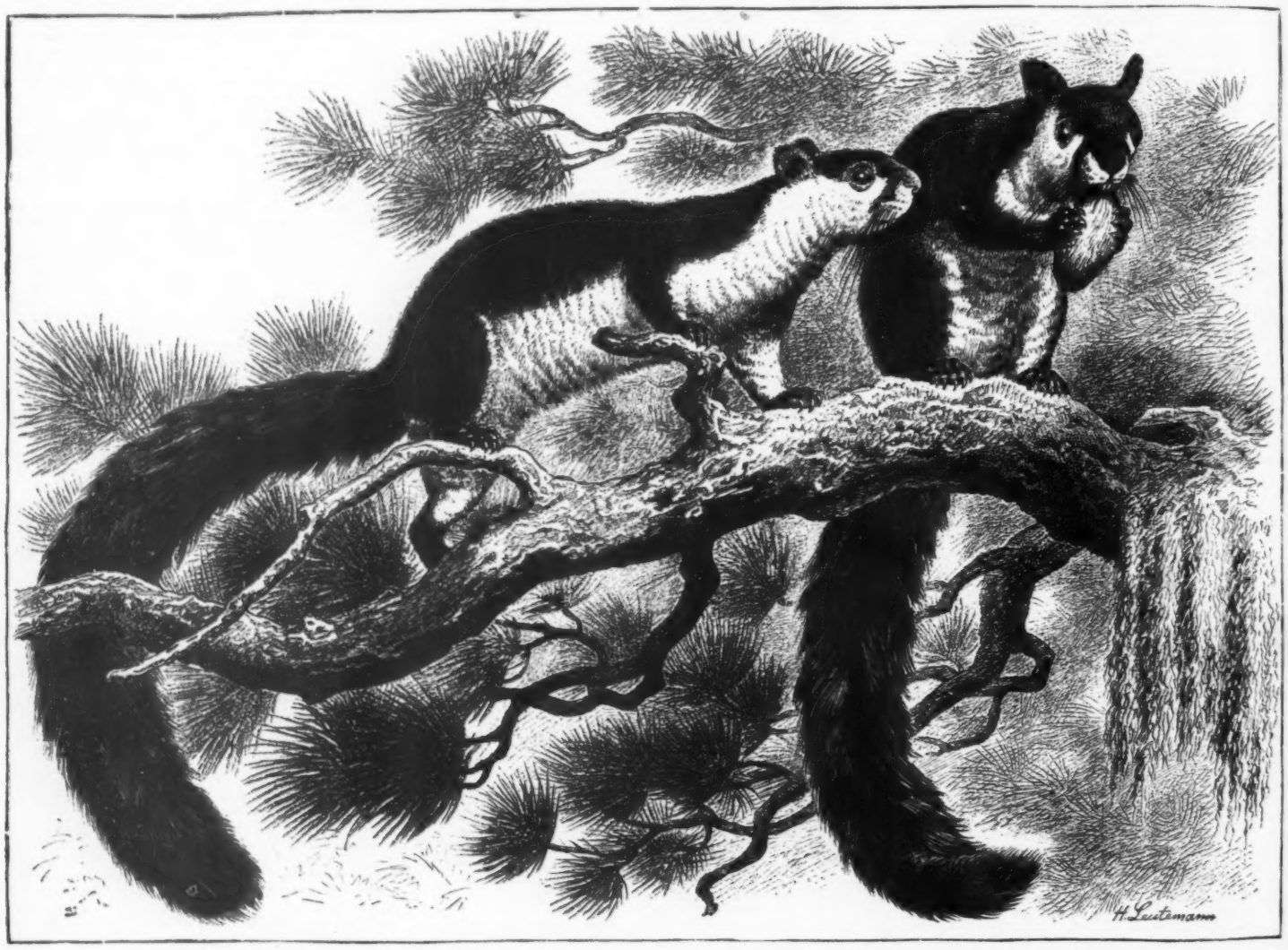
This animal belongs to the large family of *Sciurus hippurus* (horsetailed squirrel). He is about 31 inches

long, including his tail, which is about 19 inches long. This tail hangs down, like a horse's tail, when the squirrel is sitting up, but when he jumps, runs, or climbs, he carries his tail upright and bent forward as our squirrels do. The hair on his ears does not run out in long points, like that on the ears of the *Sciurus vulgaris*, but his ears are well covered, as are his feet, which are provided with strong claws. This squirrel weighs about five pounds, while our red squirrel weighs scarcely a pound. The upper part of his body and tail are deep black, but the under side, from the head to the hind legs, is ocher yellow.

The food given to the squirrel in captivity consists of bread, boiled potatoes, corn, raw carrots, and different kinds of nuts.

He can be seen running about very early in the day, but by four o'clock in the afternoon he retires to his wire cage, crawls into the bag kept there, and does not come out again until the next morning.

This rodent has a very strange friendship, though only through a wire netting, for a golden-cheeked cockatoo in the next cage, which feeds the squirrel with its hempseed and softened rolls. At first I feared that the squirrel would bite the cockatoo, or that the latter would hurt the former with its bill; but the relation is a very tender one, and these two totally different animals appear to kiss one another through the bars, but close observation shows that the cockatoo is offering food to the squirrel, which he takes carefully in his mouth. Let us hope that this friendship may last a long time



THE HORSETAILED SQUIRREL IN THE DRESDEN ZOOLOGICAL GARDEN.

for the pleasure of the public.—*Dr. Schoepf, in Illustrirte Zeitung.*

THE EARL OF ROSSE'S GREAT REFLECTING TELESCOPES AT BIRR CASTLE.

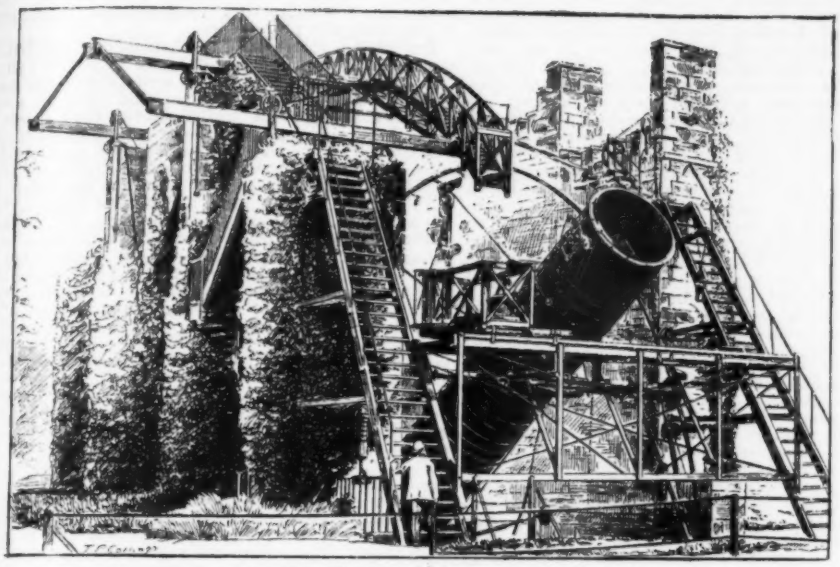
By Otto Baeddicker, Astronomer at Birr Castle.

The inhabitants of Birr, or Parsonstown—the latter name, derived from the family name of the Earl of Rosse, replaced the former ancient one by Royal Charter, about 1650—are rather fond of referring to their town as the model town of southern Ireland. Though, to some extent, this may be due to local patriotism, yet it cannot be denied that, as to cleanliness and width of its streets, and the substantial character of its houses, the town is vastly superior to most of the smaller Irish country towns. This has, unfortunately, the one disadvantage that very little remains as to ancient buildings to connect the present with the past, though the place is as old as the proverbial hills. Practically, the only bit of "Old Birr" is shown in our illustration—"the Bridge of Birr"—which, probably since the time of Queen Elizabeth, leads over the River Brosna, and which, with old houses built across it, blackenened with age, forms a very picturesque sight indeed. If we want more traces of olden times, we must turn to Birr Castle, the residence of the Earl of Rosse. It is beautifully situated in an extensive park; and if its ancient walls could speak, they would unfold many a tale of battle and murder and sudden death; of Cromwellian sieges, for instance, which left the traces of unavailing cannon balls behind them to this day. Yet all this history is forgotten, and the claim of Birr Castle to fame is based on more modern and less violent achievements, namely on its connection with the still largest telescope of the world. There it stands in the park, its walls covered with ivy as it will only grow in the green island, a monument—*aere perennius*—to the energy and perseverance not to mention the wonderful scientific attainments of its builder, the father of the present Earl of Rosse. Its diameter is 6 ft., that of its companion, the "small" telescope, being 3 ft. They are both *reflecting* telescopes; that means to say, the rays sent to us by a star are caught by a large concave mirror—the "speculum"—and are by it reflected back to the mouth of the tube, where a small plain mirror receives them and throws them toward its side. Here the observer stands and examines the image so formed by means of a magnifying glass, the eye-piece. The great difficulty in constructing such a telescope consists in producing the speculum. It is made of metal—an alloy of tin and copper—and has to be very heavy in order to avoid its bending in different positions of the tube, since this would most seriously impair its usefulness for astronomical purposes. The speculum of 3 ft. diameter therefore weighs 13 cwt., the one of 6 ft. aperture as much as 4 tons. Lord Rosse began his experiments in 1827 with the construction of small mirrors. In 1839 he succeeded in completing one of 3 ft. diameter, which is in constant use to this day. Our illustration shows the smaller telescope as it looks at present, not as originally built. For the older mounting was replaced by a more modern one by the present Earl of Rosse in 1877. It will be seen that instead of a closed tube, the telescope possesses an open framework of angle iron. The most novel portion of the mounting is, however, the contrivance for the observer; a hanging basket, movable in any desired direction, so that the observer is always able to reach the mouth of the tube. It is not much to say that this smaller telescope is quite able to meet all the (very considerable) modern astronomical requirements.

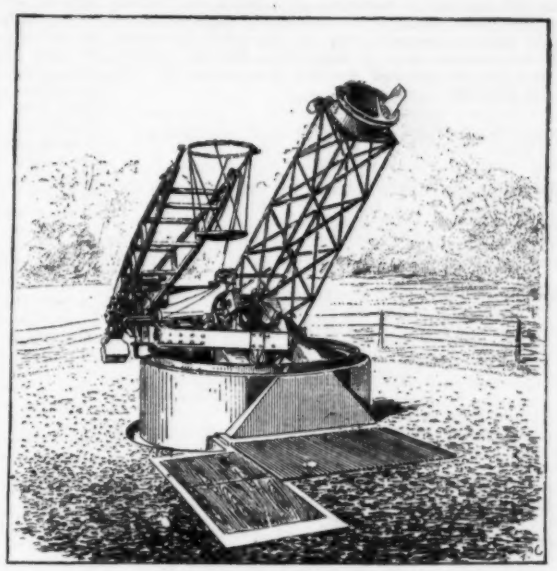
Further experiments led, in 1845, to the completion of a speculum of 6 ft. in diameter, a size beyond which no advance has since been made. Owing to the enormous quantity of metal used, three large crucibles were simultaneously used, each containing about one ton of the alloy. An ordinary mould proved worthless, as the air escaping during the casting tended to make the metal porous. Consequently, a "bed of hoops" was employed—a number of strips of hoop iron, pressed flat together by an iron rim and turned to a spherical hollow surface. Thus numerous outlets for the escaping air were provided. The first casting succeeded admirably. The mirror was placed into the annealing oven, was perfectly cool about six weeks later, but when it was to be subjected to the further operations—grinding and polishing—it was accidentally broken. The second casting was also successful. The grinding and polishing—the machinery for which was all specially designed and constructed for this purpose at Birr Castle—succeeded equally well, and a very good speculum was the result, still in existence and use. Since, however, a telescope must have two specula in order to be always ready for work—for such a speculum has to be repolished at intervals, during which time the instrument would, of course, be disabled if only one mirror existed—preparations for another casting were made. Everything succeeded; but when one morning the annealing oven was opened, the mirror was discovered to have burst into a number of fragments. Again the metal wandered into the crucibles, again a casting was made, but without success. Some of the tallow with which the mould had been greased had remained behind, and its rapid evaporation during the influx of the hot metal made the resulting mirror as porous as pumice stone. The same operations had to be gone through once more, and this time a perfect speculum was obtained, which to this day does its astronomical work. It is the chief object in our fourth illustration—reproduced from a photograph by Lord Rosse—which conveys a very accurate idea of its gigantic dimensions. As the names of the three mechanics shown in the woodcut are of historical import for Birr Castle Observatory, I may perhaps be allowed to put them here on record. On the left, close by the speculum, stands Coghlan, the smith; before him, Birmingham, his assistant; and on the right, Walsh, the carpenter. All three are intimately connected with the Birr Castle telescopes; the two former from the very beginning; the latter since, years ago, he succeeded his father. The figure in the middle is the writer of the present article.

The finished speculum is dragged on a truck from the workshop to the telescope—a feat which it takes twenty-six men to achieve—and is there put in position at the bottom of the tube. The mounting and general appearance of the large reflector are very well shown in the first illustration. The tube is built of wood, somewhat barrel-shaped, its diameter being 6 ft. at the mouth and 7½ ft. about the middle, so that it is an easy matter to walk through it with an opened umbrella. Its length is 51 ft., and this is also about the height of the walls between which the tube is suspended. On the western wall we see the galleries for the observer. They can be moved forward and backward at will, so as to bring the eye of the astronomer to the eye-piece at the side of the tube. For lower positions of the telescope a cage sliding to and fro on a large movable framework serves the same purpose. The whole instrument (as also the smaller one) lies in the open air, so that the fifth illustration—representing the observer at work about 30 feet above the ground—is certainly not exaggerated. I should also mention that the present Lord Rosse has added a clock movement to each of the two telescopes. By this the tube is kept moving at the same speed as the earth revolves, and a star, once it has entered the field, can be kept there for any length of time. Strictly speaking, however, this holds good of the small telescope only, for the range of the larger is limited by the supporting walls to about forty minutes (on the equator) from the meridian.

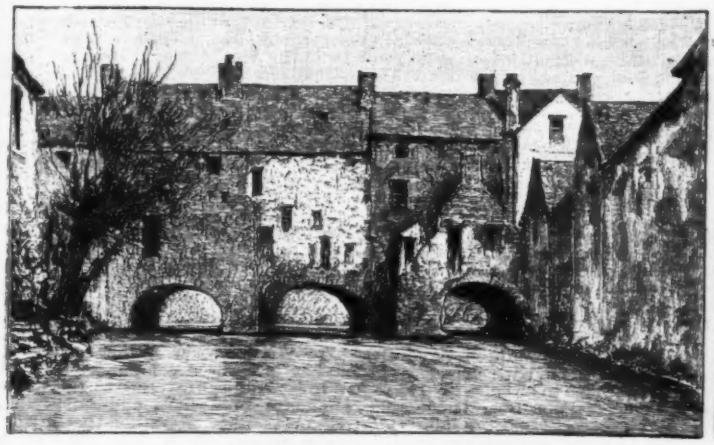
Want of space forbids my adding much concerning the work done at Birr Castle Observatory. Yet I may remark that the most important work achieved with the smaller telescope is, perhaps, the determination of the moon's heat—begun (the first of its kind) by the



LORD ROSSE'S GREAT REFLECTING TELESCOPE



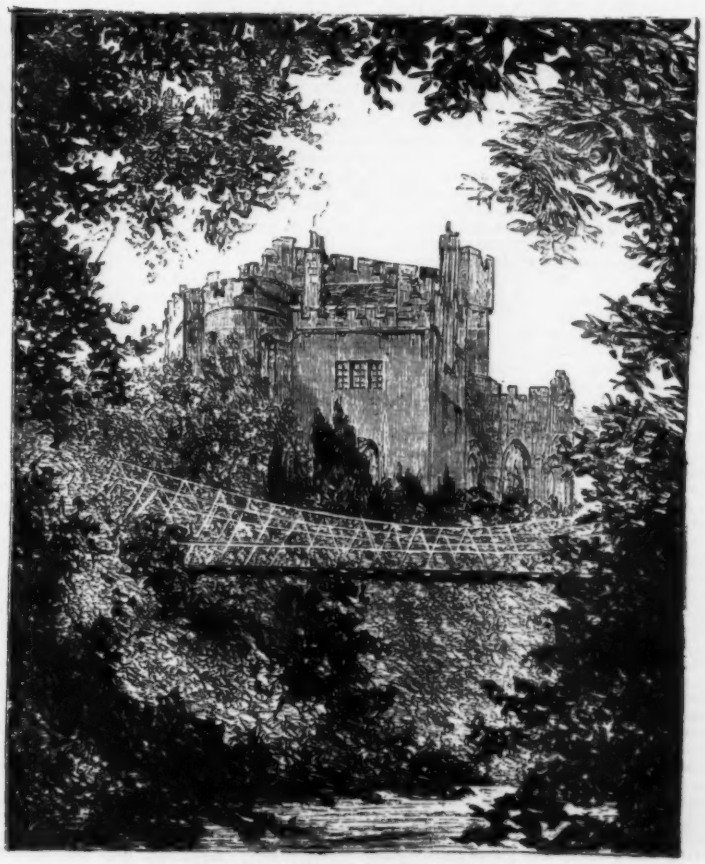
THE SMALLER TELESCOPE AT BIRR CASTLE



OLD HOUSES ON THE BRIDGE OVER THE BROSNA

THE "SPECULUM" OF THE GREAT TELESCOPE

DR. OTTO BARDDICKER OBSERVING WITH THE GREAT TELESCOPE IN WINTER



BIRR CASTLE FROM THE RIVER BROSNA IN THE PARK

EARL OF ROSSE'S GREAT REFLECTING TELESCOPES AT BIRR CASTLE, PARSONSTOWN, KING'S COUNTY, IRELAND

present Lord Rosse in 1869 with instruments of his own designing and making. The large telescope has done the work for which it was constructed, the observation of celestial nebulæ. And numerous papers in the transactions of the Royal Societies of London and Dublin show the instrument to be a striking illustration of the fact that success will come in the end to him who, by the undaunted way of struggling for the desired goal, has proved himself worthy of reaching it.—*The London Graphic.*

THE TEMPORARY STAR IN AURIGA.*

G. RAYET.

THE temporary star in Auriga, the existence of which was announced by a telegram from Mr. Copeland, dated February 1, and which was discovered by an anonymous amateur, has been observed twice with the instruments of the Bordeaux Observatory, on the 10th and 11th of February.

The position of the new star for 1892·0 is: R. A. 5 h. 25 m. 3·47 s., P. D. 59° 38' 9·5".

The new star is not given in Argelander's zones, and it is therefore probable that its previous magnitude was less than the 9th.

On the 10th and 11th, the star was about 5th magnitude, comparable with 26 Aurigæ; its color was noted as yellow orange or straw yellow.

The spectrum of the star, which I have examined twice with a spectroscope having a single prism of heavy flint, and mounted on the 14 inch Bordeaux equatorial, consists of a continuous spectrum, in which the red and violet seem very brilliant, with four bright lines or bands in the green. My measures give the following wave lengths for these lines:

First line.....518 $\mu\mu$ near b; probably b.
Second line....501
Third line.....493
Fourth line....487 near F; very probably F.

The second and third lines are the brightest; they have, as is always the case, a banded appearance.

The spectrum of the new star in Auriga differs very sensibly from that of the new star in Corona (May, 1866) observed by Huggins, M. Wolf and myself; from that of the star in Cygnus (November, 1876), described by Vogel, Cornu, Copeland, and Backhouse; and, finally, from that of the star in Andromeda (August, 1885), studied by Vogel, Maunder and Perry. The light of all these stars showed bright lines in the red and violet, particularly the lines Hα and Hβ of hydrogen; the lines of the present star are all four comprised between b and F. It must be remarked, however, that in the case of the star in Cygnus, the outer lines of hydrogen disappeared before F and the line 501 $\mu\mu$; this, perhaps, explains why the Hβ line is the only one visible in the light of the star in Auriga.

P. S. A new observation, made on the night of February 14 and 15, allows me to add to the four preceding lines the bright lines Hα of hydrogen in the red, and that of sodium.

THE AIR A NITROGENOUS FERTILIZER FOR LEGUMES.

By A. L. WINTON, JR., Connecticut Agricultural Experiment Station.

OF all the fertilizing elements required by plants, nitrogen is the most expensive, costing from fourteen to nineteen cents per pound, or over twice as much as soluble phosphoric acid, and three to four times as much as potash. This high cost is not, however, because of its scarcity; on the contrary, it is a very common element, forming over three-fourths of the air about us. Over every acre of our farms there hangs suspended enough nitrogen in a free or uncombined condition to be worth about $10,000,000 if obtained in a proper state of chemical combination with other elements, but the manufacture of nitrogenous fertilizers cheaply from the air has not yet been accomplished. We have been obliged to bring nitrate of soda and guano from South America, and sulphate of ammonia, tankage, blood, etc., from different parts of our own country to make good the deficiency of this most important element in our worn-out soils.

Recent experiments with legumes—pease, beans, clover, lupines, etc.—which show that these plants have the remarkable power of directly utilizing the free nitrogen of the air, are of special interest to the farmer, because they suggest a method whereby the expense of fertilizing with nitrogen may be diminished. During the past hundred years—and it is entirely during this period that modern chemistry, and therefore agricultural chemistry, has been developed—the source of nitrogen in plants has been the subject of numerous experiments. The early chemists attempted a solution of the problem by determining the change in composition brought about in a confined volume of air in the growth of plants. But this method is in itself defective, and for this and other reasons their results were worthless. It was not until 1850, and the few years following, that the matter was investigated in a rational manner by Boussingault in France and Lawes and Gilbert in England.

These experimenters examined the plants themselves, rather than the air, with reference to gain or loss of nitrogen. Seeds containing a known quantity of nitrogen were planted in soil free from this element, but containing all the essential mineral ingredients, and at the end of the period of growth the plants were analyzed. In no case was it found that plants thus grown contained an appreciably greater quantity of nitrogen than the seed. As a result of these and numerous other experiments, the conclusion was reached that plants could attain healthy growth only when nitrogen was present in sufficient quantity in the soil, and that there was no evidence that free atmospheric nitrogen could, under any circumstances, be assimilated. These conclusions were accepted by scientists as final, and, during the twenty-five years following, further experiments were not attempted. Notwithstanding the scientific evidence, it was a well known fact that legumes could thrive on soil which, owing to lack of nitrogen, could not support other plants.

Between 1880 and 1885, Professor Atwater, of Wesleyan University, Connecticut, obtained results which showed that the pea plant is an exception to the general rule, and can acquire free nitrogen from the air. His results were at first received with distrust, but, in 1886, Hellriegel, a German chemist, and afterward others, verified Atwater's work, and proved beyond a reasonable doubt that not only the pea plant, but many, if not all, legumes have this remarkable power. It was soon ascertained that microbes in the root tubercles are instrumental in bringing about this acquisition of free nitrogen. These little root tubercles had long before been noted on roots of legumes, but their true significance was not understood. Hellriegel found that when these plants were grown in pots of sterilized soil, containing no nitrogen at all, root tubercles did not form and the plants soon sickened and died; in cases, however, where a little garden soil had been added at the proper time to the pots, the tubercles soon began to appear, and healthy growth to complete maturity followed. The best results were obtained if the earth with which the plants were infected was taken from a garden which had previously grown the particular legume under experiment.

Nobbe, a German botanist, who has long been before the public as an expert on seeds, has recently performed some experiments, the results of which, published only a few weeks since, throw new light on this subject. Seedlings of various herbaceous and woody legumes were set out in pots of soil containing mineral salts, but so prepared as to be entirely free from nitrogen and also from living microbes. The pots were then infected with various solutions, each of which contained a pure culture of a microbe from the root tubercles of some legume. Although these pure cultures from different legumes could not be distinguished from each other by microscopic examination, their effect on the various legumes was very different. For example, the infection with the locust microbe produced very beneficial results on the locust plant, but with the pea plant and other legumes scarcely any effect was noticed; on the other hand, the pea microbe brought about a vigorous growth in the pea plant, but had little influence on the locust.

In many cases infection with the proper microbe produced as good results as the addition of a liberal quantity of nitrogenous manure, while without infection the plants soon sickened and died. The practical conclusions derived from these experiments show plainly that, with our present knowledge of the habits of legumes, these plants ought more than ever to become prominent factors in agriculture. It has been clearly demonstrated that clover, beans, peas, lupines and other plants of this family, can be successfully cultivated on soils where, owing to lack of nitrogen, other crops will not thrive.

It is, therefore, a waste of time and money to apply nitrogenous fertilizers to such crops when the cheaper material containing only potash, phosphoric acid and other mineral ingredients will act with as good effect. A soil which has never grown legumes may not contain a sufficient number of the germs which are instrumental in rendering these plants capable of utilizing the free nitrogen in the air. In such cases the addition of about half a ton per acre of soil from land which has previously grown the particular legume to be cultivated may produce as beneficial effects as a liberal dressing with nitrogen. This point is especially worthy of notice by those introducing into a locality new kinds of legumes.

FIELD PEASE OUR GREAT FERTILIZER.

As the season for planting field pease is again approaching, the best dates for such planting seeming to be between May 15 and June 15, the utility of such work is a proper matter for consideration. The wonderful effects of field pease upon our Louisiana land have been comparatively inexplicable. The physical effect upon the soil brought about by the tap roots of the plants penetrating therein, and the so-called nitrification of the soil caused by its shading by the broad-leaved pea plant, are the causes to which the resulting benefits are usually ascribed. These have seemed hardly competent to cover all the good that results from the planting and production of pease in our alluvial lands, and an article on *The Air a Nitrogenous Fertilizer for Legumes*, by Mr. A. L. Winton, Jr., of the Connecticut Agricultural Experiment Station, which we republish in this issue, is very interesting in its statement of the recent discoveries as to how these plants produce such wonderful effects upon the soils wherein they are grown, and the article is worth a careful study.—*La. Planter.*

PRINCIPLES OF POTATO CULTURE.

WHAT potatoes now would have been but for the appearance of the too notorious fungoid disease which has proved the most terrible enemy either the tuber or cultivator of vegetable products has had to contend with, it is indeed difficult to assume. It is just possible, in some respects, that they would be better than they are, in other respects less good, especially in the matter of productiveness. The disease has been with us half a century, for it made its appearance in Great Britain in 1845, though scarcely at no other time with such destructive effect as in that year. Still we have had many most destructive visitations, and it is only during the past twelve years or thereabout that any real grappling with the fungus through the introduction of really disease-resisting kinds has been brought about. It is perhaps wonderful that almost, if not absolutely, the only variety of potato which has lived through that long period and sustained an excellent reputation has been the old Ashleaf. The probably older green-stemmed Walnut Leaf form has perhaps almost become extinct, but the purple-sprouted and freer-growing Ashleaf has kept in existence in a truly wonderful way. How long that variety has been in commerce no one perhaps can tell, but it would be a matter of exceeding interest could its origin be fully elucidated. We have had seedlings, etc., also selected Ashleafs, put into commerce with various names attached, but there seems no reason to doubt that pure tuber stock of the original Ashleaf still exists, and is as good as any of its progeny.

The fact proves beyond a doubt that, if ordinary care be taken of the stock, the capacity of any variety of potato to endure seems to be illimitable. Doubtless the Ashleaf Kidney owes much of its enduring powers to the fact that being so early in maturing it commonly escapes the disease, the tubers being fully ripened, and also that because so early in sprouting, even in winter more care has been bestowed in keeping the seed stocks sound and full of vigor than has been the case with most other kinds. Still further, it has found very few competitors early enough in maturing to put them into prominence.

But what is thus said of the Ashleaf does but demonstrate one of the essential principles in potato culture and its value. It is that the seed tubers shall have every possible care taken to maintain them in a condition of hard, robust health during their season of rest. Fifty years ago, and before the disease fungus was dreamt of, we had then hardly more perhaps than some half dozen only very moderate varieties of potatoes in cultivation. Besides the Ashleaf there were the old Fortyfold, Jersey Blue, Lancashire Kidney, having a pink skin, and one or two others. All of these varieties, especially those grown for main crops, were incapable of resisting disease to any appreciable extent. Indeed, the slaughter in 1845 was so terrible that a potato famine almost resulted. So distressing were the effects of this and following disease attacks that for a time it was feared potato culture would have to be put aside altogether. Happily some excellent potato growers conceived the idea to raise seedlings, and among these Paterson, of Glasgow, was one of the most famous, and he put into the market many then very estimable varieties. Still, few of them endured; indeed at the present moment, so fleeting is fame in this department of horticulture, that probably not one of Paterson's sorts is in cultivation. Still he did much good in furnishing varieties which helped to carry on the war against the fungus, though for many years almost without avail. However, we imported American varieties, indeed literally flooded the markets with them. These were still very largely amenable to disease attacks, but had in them germs of robustness which our own stocks did not possess. They were very prolific, far beyond what British varieties were, and when our raisers married the American stocks to ours there began to arise a race of potatoes which have developed into very robust disease resisters, and the effect has been remarkable. Clarke, who gave us that potato wonder of the Victorian era, Magnum Bonum, found the seedballs from which it came on Early Rose, and he believed that the pollen parent was Paterson's Victoria. We have now plenty of Magnum Bonum seedlings under different names, and so prolific are they that we now find in midwinter, and after a season of more than usual fungoid destructiveness in the potato crops, that potatoes are so abundant that they can be purchased in plenty at two shillings per bushel, and perfectly sound. That our existing sorts are enormously productive, as compared with the best of fifty years ago, there can be no doubt. Perhaps in all cases there is a deficiency of that deliciously nice flavored and nutty quality found in the old Fortyfold and Regent, but that is no fault of raisers. Potatoes of delicious quality have been raised during the past thirty years in myriads, but they, because of their fine quality, have always proved more susceptible to fungoid attacks—hence they have been compulsorily set aside. We have had to regard healthy crops as the first consideration, abundant ones next, and quality last of all. It is not our fault, but rather that of the destructive potato disease. Now, there are two great matters to guide us in our cultivation of potatoes. First, and naturally most important, are such forms of cultivation as shall enable our crops to escape the disease. The second is the securing of an abundance of good clean produce of the best quality.

We have had through a long series of years many diverse disease-avoiding methods of culture recommended to us, but few have been successful. The best advice invariably has been to plant only hard, well matured, and properly stored seed tubers; to have the soil well drained, either naturally or artificially, and deeply worked. It is astonishing to find how much deep cultivation acts as drainage, and facilitates the passing off of surplus moisture, on the one hand, while it enables the moisture in the subsoil to ascend when needed in hot, dry weather. Then it is unwise to plant potatoes in immediate contiguity to fresh manure. That is always provocative of evil when the fungus abounds. Farther, the plants should have ample room—far more, indeed, than is usually given. As a rule, in fields especially, we plant just one-third more of tubers on a given area than should be planted. Almost invariably the plants are too crowded, and in spite of, perhaps, plenty of sunshine, disease prevails, and the breadths suffer far more than in those where planting is thinner. All late robust growers should have intervals of three feet fully between the rows, and the plants in the rows should be fully fifteen inches apart. Then it is well to rely for crops almost exclusively upon first earlies, such as the Ashleaf, Beauty of Hebron, and similar precocious sorts; and the latest, most of which are disease resisters. The mid-season varieties more generally fall a prey to the disease than do others. The wider space between the rows enables earthing up to be done more liberally. Whatsoever virtue there may be in the Jensen system of protective earthing—and the merits have not anywhere here had a very conclusive trial—it is certain at least that the more ample the earthing, the more are the new tubers protected from heavy rains in consequence, also from the minute fungoid spores which, if Jensen's theory be correct, are washed down through the thin coating of soil usually left over the young tubers, and thus penetrate and finally infect them. As to the employment of the Bouille Bordelaise mixture for destroying fungoid germs, that only comes in as a principle in cultivation so far as it finds faith in the growers. In some directions it has been tried with great success, in others with poor results. None the less should it have a fair trial very generally during the coming year. Those who want to secure fine exhibition tubers should begin by selecting their seed tubers, and disbudding them to one or at the most two buds or shoots. They should plant not earlier than the end of March, in light, fine, deeply worked soil, not too rich, and giving an abundance of room. Add a dressing of superphosphate of lime at planting time, as it is a most valuable potato manure. Earth up neatly, carefully and liberally, keeping the stems thin than otherwise. A fine crop of very handsome tubers can hardly fail to result.—*A. Dean in The Gardeners' Magazine.*

* Translated from *Comptes Rendus* (Paris), February 15, 1892.—*Astronomy A. P.*

CAMPHIRE AND CAMPHOR.

By J. CH. SAWER, F.L.S.

IN the 14th verse of the 1st chapter of the Song of Solomon we find: "My beloved is unto me as a cluster of camphire in the vineyards of Engedi." At first sight the meaning of this verse is obscure. The word translated "camphire" is certainly not intended to convey to the mind any idea of the substance we now know as camphor. Solomon was very happy in his choice of similes, and such a comparison would have been absurd. In the original of this poem or love song, written about 1,000 years B. C., the word translated camphire is *copherim*, the Egyptian equivalent of which is *hennah*. In Egypt, on one of the nights before a wedding, "hennah" is applied with linen bandages to the hands and feet of the bride until the next morning, when they appear of that rosy red which Egyptians believe to be love's proper hue. This night, in the order of the marriage ceremonials, is called the night of the "hennah." The word "cluster," found in the text, no doubt refers to the flowers of this plant, which are of a golden yellow and are borne in clusters; they are remarkably fragrant whether fresh or dry, and were much esteemed by women in the East, especially the Jewish women, who carried bouquets of them in their bosoms and twined them into crowns for their heads.

This hennah is Pliny's "Cyprus of Egypt," and the women of Egypt and other Eastern countries stain not only the palms of their hands and the soles of their feet with a paste of hennah leaves, but also the tips of the fingers, the nails and the knuckles, from which custom probably arises the designation of Aurora as "rosy," or "rosy-fingered" (ῥοδοδακτυλος ἠώς).

A considerable business is done in the leaves of the hennah, which are collected in the green state and dried in the sun. The leaves are then coarsely powdered and beaten up with catechu, and the freshly made paste is laid on at bed time and renewed in the morning; it leaves a peculiar reddish-orange stain, ruddy, and somewhat similar to the color of red ocher, though hardly so deep, which lasts on the skin and nails for some three or four weeks, until removed by renewed growth. This coloration is much admired by Mussulmans in India and many Eastern countries.

On moistening the dried leaves a slight odor is perceptible; their taste is bitter and faintly aromatic, owing to an essential oil and tannin contained in them. A medicament prepared from them is employed by the Arabs in the treatment of wounds of all kinds, causing the skin to grow over and healing them very quickly; these effects are probably due to some exciting action of the essential oil and the astringent properties of the tannin. They use this remedy principally on horses, to heal wounds or sores caused by friction of the harness or otherwise on a journey. Having stopped for a rest and unsaddled, they will apply a plaster to it and continue their march without more thought of the wound, which, if it does not heal, at least does not extend by friction, and causes less suffering to the horse. They also employ it as a means of preventing the opening of old wounds where the hair has not grown over the scar. It closes and hardens the tissues—in fact, tans the skin. For similar reasons, the Arabs who can afford to indulge in the sport of gazelle hunting will give their horses a foot bath of hennah, especially if the animals are young, or have not taken exercise for some time. There may be some analogy to this in the custom prevailing among Arabian women of staining the palms of their hands and the soles of their feet—it may render the skin less tender.

This shrub, being known to the Arabs as "henne-al-hennah," appears to be a native of Arabia. It has been cultivated from earliest times, and is now very common throughout India, Cabul, and Persia, as well as along the coast of the Mediterranean. Botanically it is now known to us as the *Lawsonia inermis* of Linnæus. It flowers and seeds most of the year, and is much used for hedges, growing readily from cuttings. It has been introduced into the West Indies, and is there known as Jamaica mignonette. The perfume of the flowers is rather a mixture of rose and mignonette. Acids destroy the dye yielded by the leaves, but alkalies and infusions of astringent plants deepen it; although this juice stains the epidermis, it does not communicate any color to cloth.

The name of the white crystalline substance commonly known as camphor is derived from the Arabic word "kafur," which in its turn was derived from the Sanskrit word "kapura," signifying *white* or a pure substance.

The old English name for camphor was spelt *camphire*, and as the translators of the Bible may have been unacquainted with the botany and natural history of the plant hennah, they may have confounded the Hebrew word "copherim," or "kopher," with the Arabic word "kafur." This is pure surmise, but evidently the word "hennah" should be substituted for the word "camphire" in the Song of Solomon. Moreover, there is no record of the substance kafur, or kapura, being known in Solomon's day.

Camphor is first mentioned by Arabian writers in the sixth century. It is mentioned by Aetios, of Amida, in Mesopotamia, according to whom kaphura is a rare and wonderful medicine. It is again mentioned, together with musk, amber, and santal wood, among the treasures taken in the year 636, by the Kalif Omar, at the plundering of the Sassanides Palace, in Madain, on the Tigris, and is subsequently noticed as a costly gift, often presented by Indian princes to high Chinese officials. This camphor came from the land known as Kaisur, the present Sumatra.

Ishak Ibn Amran, an Arabian physician, who lived toward the close of the ninth century, states that the best camphor was produced in Fansur, a locality which was visited by Marco Polo in the thirteenth century, who mentions that the Kaisur camphor was then marketable at its weight in gold.

From various sources of information it may be concluded that camphor, as it was first known, was the variety which exists ready formed in the pith cavities of the trunk of the *Dryobanalops camphora*, a magnificent tree growing in Borneo, Sumatra, and Labua. In the forests of Sumatra these trees attain an immense size, often being found of six or seven feet in diameter. They do not all contain camphor, many of them containing an oil, which is supposed to be the first stage of the formation of the drug, and would develop into camphor were the tree left unmolested. Both oil and camphor are found in the heart of the tree, not occupying the whole length of the pith cavity, but often in spaces of a foot or a foot and a half in length, at intervals. The method of extracting the oil is merely by making a deep incision with a Malay ax about 14 or 18 feet from the ground, till near the heart, when a narrower incision is made, and the oil, if any in the tree, gushes out, and is received in bamboos or other utensils. In this manner a party proceeds through the woods, wounding the camphor trees till they attain their object. From a tree containing both oil and camphor, two gallons of the former and three lb. of the latter may sometimes be obtained, but hundreds of trees may be mutilated before camphor is discovered, as the natives have no certain means of ascertaining if the tree produces either the one or the other. When camphor is found, the tree is felled and cut into junks of a few feet long; these are then split, and the camphor is found in the heart, occupying a space in circumference of the thickness of a man's arm. The quantity varies from three to fifteen lb., and rarely as much as twenty lb. are obtained. Some trees when felled are not found to contain any at all. The camphor thus found is called *tentary*, and by reason of the small quantity, it commands a high price—from 35 to 70 shillings a pound, according to quality. It does not find a market in Europe at all, but is used to some extent on the spot as incense, especially in the observation of funeral rites and embalming the bodies of the dead, and is exported to China, Japan, and other places in Eastern Asia, for similar purposes. It is heavier than laurel camphor, and sinks in water.

The date at which the Chinese discovered the production of camphor from the *Laurus camphora* is unknown. This is called laurel camphor, or "common" camphor. It was brought into Europe by the Arabians about the twelfth century, which is proved by the mention made of it by the Abbess Hildegard ("St. Hildegardis Opera Omnia," 1145, published in Paris 1855), who called it ganphora. Garcia de Orta, writing in 1563, states that the Chinese is the only camphor imported into Europe; that of Borneo and Sumatra, being a hundred times more valuable, is retained by the Orientals for their own use. Kampfer (strange coincidence of names), who visited Japan 1690-92 and made a drawing of the Japanese camphor tree under the name of *Laurus camphorifera*, expressly declares that the tree differs entirely from the camphor-yielding tree of the Malay Archipelago. He further states that the Borneo camphor is one of the most precious articles of merchandise imported into Holland from Japan. This camphor was refined in Japan by a process long kept secret.

The common camphor tree, *Laurus camphora*, is distributed throughout the eastern provinces of Central China, on the island of Hainan, and very extensively in Formosa. It also occurs as a forest tree on the islands Kiushiu and Shikoku of South Japan, its growth being much more vigorous there than in the more northern districts. The camphor of European commerce is produced almost exclusively from the camphor laurels of Formosa and Japan.

The large and increasing quantities of this drug consumed in all civilized countries make the question of its continued production and regular supply a matter of considerable importance. It is a well known fact that the distillation of the crude camphor from the wood is conducted in a primitive, careless way, which causes great waste. The camphor laurels of Formosa are gradually being destroyed under the careless systems employed by the Chinese gatherers; in fact, they have been entirely exterminated along the seaboard, and the wood is now obtained in the forests along the frontier, between the settlements of the Chinese and the inland mountainous regions still occupied by the aboriginal population. The camphor gatherers are hence continually exposed to the assaults of the natives, which interrupt the profitable prosecution of this industry. No attempts are made to cultivate laurels to take the place of those destroyed, and a sufficient quantity of the drug is only obtained by constant encroachments upon the territory of the Formosans, destroying the trees still further into the interior at every new move.

The method of extracting the camphor is as follows: The trees are felled and the small branches chopped up. These, with the chips and twigs, are alone used, the heavy wood being abandoned. A long trough, made of a hollow tree, and coated with clay, is placed over eight or ten hearth fires, and is half filled with water. Boards, perforated with holes, are put across the trough, and above each hole is a jar filled with chips of the wood, with earthenware pots inverted above them, the joints being made tight by hemp and clay. The water in the trough is heated to boiling, and the steam passing through the holes saturates the chips, causing the camphor to sublime and condense in crystals in the inverted pots above. The camphor thus obtained is sent from the interior of the island to Tasmia, the principal port, packed in baskets covered with cloths and large leaves. On arrival it is repacked in tubs or lead-lined cases for export by Chinese vessels to Hong Kong, Shanghai or Canton, the loss by evaporation while in transit from the place of its production being very large. A yellow oil exudes from the packages of this crude camphor, locally known as "oil of camphor," and is used medicinally. The Formosa camphor, which sometimes goes by the name of "Chinese camphor," occasionally arrives in India in a semi-fluid state, owing to the addition of water before shipment.

The Japan camphor used to be extracted, according to Kampfer (the authority above referred to), by boiling the wood with water in an iron kettle, and condensing the vapor in an earthenware dome, closed at the top with rice-straw. The modern practice is to distill the wood with water in an iron retort fitted with a wooden dome, from which the vapors are led through a bamboo tube to the cooling apparatus. This consists of a wooden box, containing seven transverse compartments, and is inclosed in a second box, through which water is allowed to flow; the vapors are conducted through all the compartments in succession by means of holes placed alternately at either end of the dividing walls. The Japan camphor arrives dry; it is lighter in color, and somewhat pinkish. It arrives in double tubs (one within the other) without metal lining; hence it is sometimes called "tub camphor."

The European process of refining camphor was long kept a secret, and toward the end of the seventeenth century the entire camphor of Europe had to be sent to Holland to be sublimed. A monopoly was also held for some time in Venice, but at the present day camphor refining is largely accomplished in England, Holland, Hamburg, Paris, New York, and Philadelphia. Before describing the correct European method, it may be well to describe the fraudulent method adopted in India, the artful peculiarity of which is to get as much interstitial water as possible into the camphor cake. The vessel used is a tinned cylindrical copper drum, one end of which is removable; into this is put 14 parts of crude camphor and 2½ parts of water; the cover is then luted with clay, and the drum, being placed upon a small furnace made of clay, is also luted to the top of the furnace.

In Bombay, four of such furnaces are built together, so that the tops form a square platform. The sublimation is completed in about three hours; during the process, the drums are constantly irrigated with cold water. Camphor sublimed in this way is not stored, but distributed at once to the storekeepers before it has had time to lose weight by drying. It is sold at the same price as the crude article, the refiner's profit being derived from the introduction of water. The same practice seems to be followed at Delhi, and at a few other cities in India.

In Europe, it is usually refined by mixing it with lime, charcoal, or iron filings, and subliming the mixture in large glass vessels; cakes weighing eight to twelve pounds being thus obtained.

The process adopted in Philadelphia is devised in such a way as to obtain the sublimate in the form of a finely powdered, snowy mass, to accomplish which about one-tenth per cent. of water is added to the crude material. The apparatus consists of a flat iron chamber, capable of holding about 200 lb., connected by means of an iron tube with a condensing chamber eight feet long, four feet wide, and four feet high. This chamber is constructed of enameled bricks set in Portland cement, forming an arched roof and floor of the same material. After an operation the apparatus is allowed to remain undisturbed overnight, to become sufficiently cool. On removal of the sublimate, it is compressed into moulds by hydraulic pressure of 2,500 lb. to the square inch, and the finished product obtained in small cakes, highly compressed, and weighing one ounce.

Camphor forms a tough, crystalline mass of characteristic taste and odor, and can only be powdered when it is moistened with alcohol or some other solvent. It dissolves in 1.300 parts of water at 20° C., and at 12° C. in 0·8 part of alcohol of sp. gr. 0·806. It is readily soluble in ether, acetone, chloroform, benzine, and other hydrocarbons; also in glacial acetic acid and in carbon disulphide. It melts at 175° C., and boils at 204° C., but volatilizes very rapidly at the ordinary temperature and sublimes, when kept in close vessels, in lustrous hexagonal crystals, which frequently form splendid stars.

Camphor oil is used for mixing with fine lac varnishes, rendering them less liable to crack. It is a powerful antiseptic and disinfectant, and covers the smell of mineral oils.—*Knowledge.*

THE HONEY STRAWBERRY.

IN a letter to the *N. E. Farmer* Mr. S. L. Watkins says: Few persons are aware that in the Sierra Nevada mountains there is a variety of wild strawberries that stands unrivaled in the abundance and superiority of berries produced. It is a perfect flowering variety and is exceedingly valuable as a fertilizer among pestillate plants.

My attention was first directed to these berries by a Mr. Smith of this county, who states that several years ago he discovered near one of the springs on his place a wild strawberry plant of wonderful production, that bore medium sized berries of an exquisite flavor. They commenced to bear extra early, considering his location, which is 3,600 feet above the sea level, and continued fruiting and blossoming until the late frosts came. Mr. Smith dug up 25 of the plants and gave them a thorough trial and was so struck by their good qualities that he immediately started a patch of 300 or more and in time enlarged to a patch of 300 plants. Last season I found himself and family busily engaged in picking berries.

Viewed from a short distance there were enough ripe berries visible to give the entire patch a beautiful coloring; the atmosphere around was charged with a delightful, spicy, strawberry aroma; in fact, I know of no other variety of strawberry that will bear comparison with this California variety for fragrance. The berries are exceedingly sweet, juicy, aromatic and delicious, melting in the mouth without a particle of hard core. The fruit is oblong in shape and when fully ripe a beautiful crimson. The leaves are delicate and finely cut and in time form a rounding symmetrical plant. The berries hang very thick on the plants. I counted 65 ripe berries on a single plant, and found numerous young shoots loaded with blossoms and young berries of all sizes, and this plant was not an exception. The berries are not large, but by proper cultivation berries can be produced that are three-quarters of an inch in length. I know by experience that it does not take long to pick a box full. In addition to the above good qualities they are enormously prolific, and in favorable localities will blossom and produce fruit for ten months in the year.

In their native home, the upper Sierras, they bear fruit eight months in the year, and would bear longer but for frosty and snowy weather. They are wonderful propagators of their own kind and one plant will probably throw out 100 runners in a season. Young plants will bear a good crop the same season.

All growers know that occasionally there is met with in all varieties of strawberries a plant that is more thrifty than the rest, and which produces larger and finer fruit; it is one of these plants that originated the variety on Mr. Smith's place.

California wild strawberries in their native home grow in some of the most unpromising localities, and they would no doubt thrive well on poor soils.

On account of their delicious sweetness and delicate aroma, this new and improved variety will be known under the name of "honey strawberry."

As the honey strawberry is a perfect flowering vari-

ety, the field for hybridizing and crossing with other varieties to produce a more perfect berry still is almost limitless, and I expect this plant will play a prominent part in the originating of new berries.

S. L. WATKINS.

LIFE SAVING DEVICES.*

USES OF THE KITE.

A MEMORANDUM was addressed in December last to the secretary of the Liverpool Salvage Association by Mr. D. Chisholm, chief surveyor and wreck agent. It is as follows: "Seeing several paragraphs in the papers with regard to the saving of lives at sea and from stranded vessels, I cannot let this pass without giving my experience on the ship British Viceroy, of Liverpool, when stranded at Dunany Head in February, 1875, when laden with a general cargo. I left Liverpool in one of the Old Tug Co.'s tugs, with a gang of riggers, to dismantle and refloat the above named vessel. We had not been on board six hours when the gale freshened from the eastward, so much so that the tug could not come near us for fear of striking the rocks, and we were too far out for the rocket apparatus to reach. We therefore had to batten ourselves down in the cabin, the stern of the ship being to seaward. The heavy sea rolling on the beach prevented the coastguard, ship's crew, and my rigger men and myself from leaving in the ship's boat; consequently, we had all to remain on board for nine days. All this time I sent telegrams and letters on shore with a kite that we made out of a bread bag, the frame of which was made from the hoop of a beef tierce, and the carpenter made the backboard and stretcher. The crew made the tail out of rope yarns, others of the crew rolling marline on to a stick, and in about twenty minutes we had our messenger flying, and when well in the air we attached a piece of wood to the bight in the kite line, and then paid out the line from the ship until the wood was carried on shore, and then our agent got the line and ran the kite down and received my dispatch. He was told to put what letters and newspapers he had for us in the pocket at the back of the kite, and fly the kite again, and hoist his white pocket handkerchief as a signal for us to haul on board, which we did, and got our news. This was a daily occurrence while the gale lasted. On the seventh we got short of potatoes. We then thought if we made a larger kite we could attach our jolly boat as a buoy and get a small sack of potatoes. This was carried out with success without a man wetting his feet.

HOW TO USE THE KITE.

"Any one interested in this sort of communication can see the first kite we used on the British Viceroy by visiting the Liverpool Salvage Association or the underwriters' pump shed, Canning Pierhead. Mr. Marsh, our chief engineer, made me a folding kite, which can be put into a box when emergency occurs. To establish communication with a stranded or disabled ship, which cannot be approached by boat, communicate by floating buoy; communicate by rocket or line-throwing gun; or construct a kite of calico of suitable size, fly the kite from windward of the ship, and let the kite tow to the vessel a buoy, etc., to which attach a line. In a pocket at the back of the kite you may place a letter which instructs those on the wreck or shore as to the plan which it is proposed to pursue. A kite may easily be constructed large enough to tow a boat if necessary. For general purposes the kite recommended is five feet by three feet of calico, having three pockets in the tail made of calico, and kept open by rattan frames. The pockets may fit into one another, and the framework of the kite may be fastened by screws, so that the whole may be readily packed and stowed away. In use the kite is made to tow a buoy, and to this buoy is attached a stout line, by means of which a hawser may be passed. Provisions may be towed off by kite to a disabled ship which cannot be approached by boat. The provisions may be inclosed in a water-tight barrel or case or bucket. The best water proofing consists of resin and tallow, mixed in such proportions as not to brittle at the temperature of the sea."

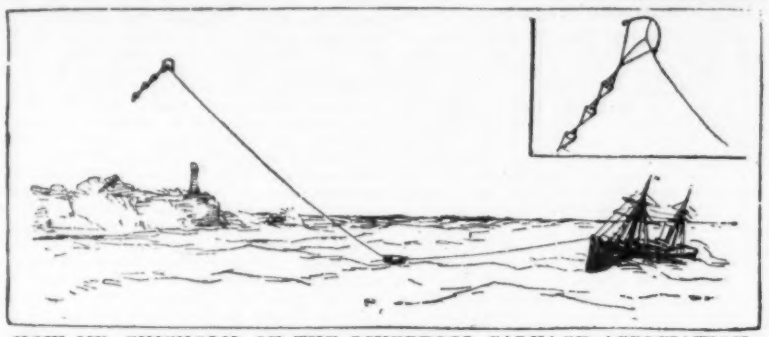
The sketches sent by Mr. G. E. Hall are of a design for a drift buoy. Of those we reproduce, the one on the left shows the buoy complete, the one on the right a section of the buoy and the paddles. The means to be used to drive the paddles would be the wind. The paddles would be cup shaped, with a square projection at the top. The wind entering the cups would send the paddles round, and the square projecting piece would strike the water and drive the buoy onward. The projections from under the buoy are called grappling fins by the designer, the idea being that these would catch in the sand or other material on shore. The buoy would, of course, carry a line.

In the design sent by Mr. J. Daw, Jr., the idea furnished by the torpedo is utilized. One man, by means of wires, is given full control over the machine. It is described by the lettered details given below. In Fig. 1, A is the tube by which the cable, B, is discharged. The cable, B, is first attached to a switch board (see Fig. 4), the two upper wires (L) working the steering and the lower (M) are for firing the rocket. The battery would also be attached to the switchboard. C is the rudder for steering; D, the screw worked by the machinery, F; G is the keyhole for winding; H is the steering motor; I, the oil box for same; J J, rocket and line fired by means of an electric spark; K is ballast, L is the wire for working motor; N is a false keel; O, an India rubber collar to protect the rocket, J, from the wet; P, a mast for flag or light. Fig. 2 shows the means of connecting the cable, B, with L and M. Fig. 3 is the plate on which the plug, L, works to form the connection. M, in Fig. 2, is a band passing round the drum, B B, and working on M M. Fig. 5 is a section showing the air belt, R, passing round the torpedo just below the water line, and the position of ballast and machinery, the dotted lines showing electric wires.

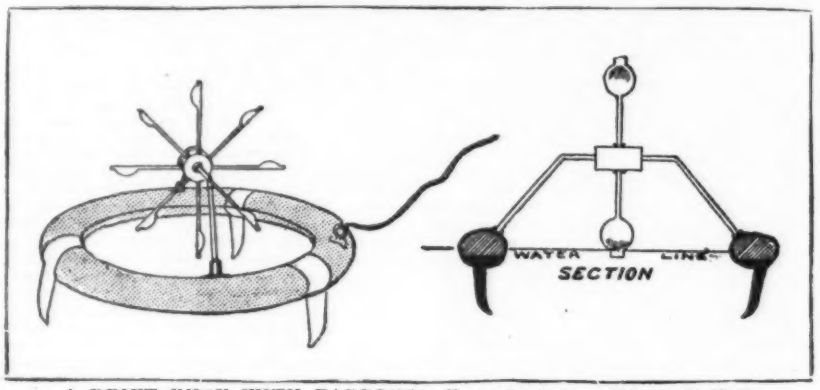
Mr. W. F. Dickes' suggestion is really that of an unsinkable punt. The hull, he says, should be made of boiler plates like an oblong tank, flat bottomed, but pointed at the bows. It should have two pipes passing transversely through it upon the water line, well riveted into either side to accommodate outrigger spars. It should also have a vertical pipe riveted be-

*Continued from SUPPLEMENT, No. 851, page 13593.

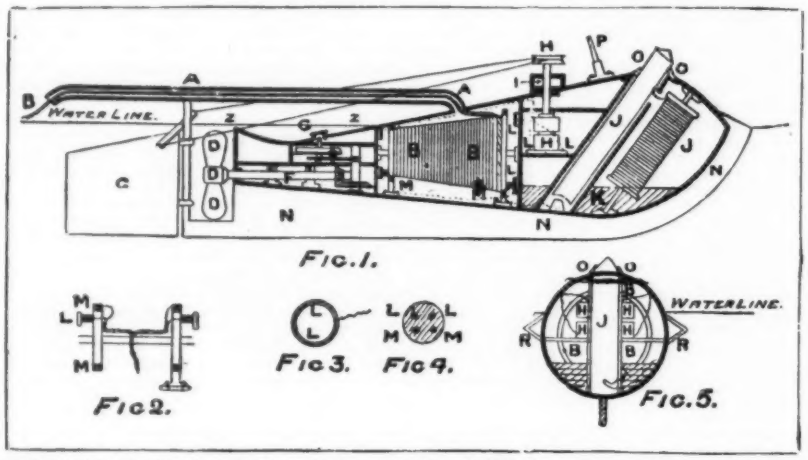
The kite, with pockets in the tail



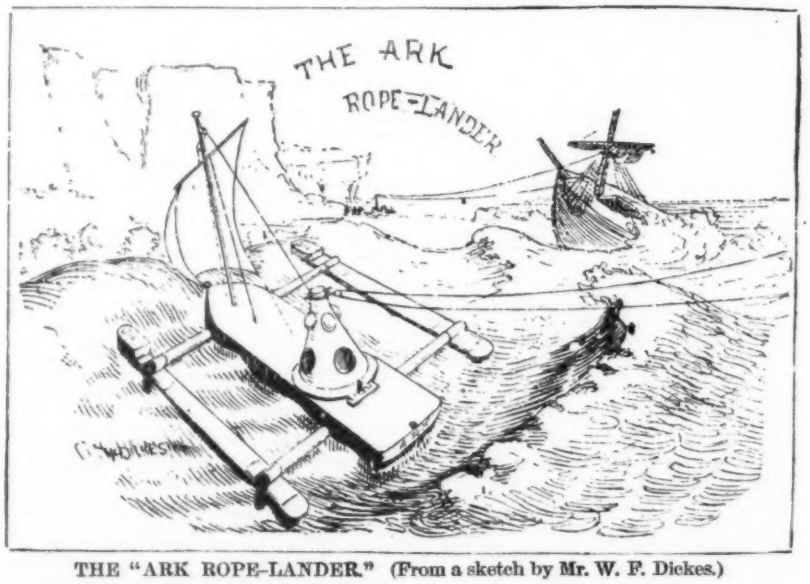
HOW MR. CHISHOLM, OF THE LIVERPOOL SALVAGE ASSOCIATION, EMPLOYED THE KITE.



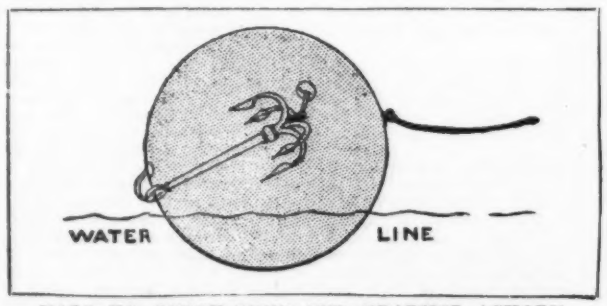
A DRIFT BUOY WITH PADDLES. (From the design of Mr. G. E. Hall.)



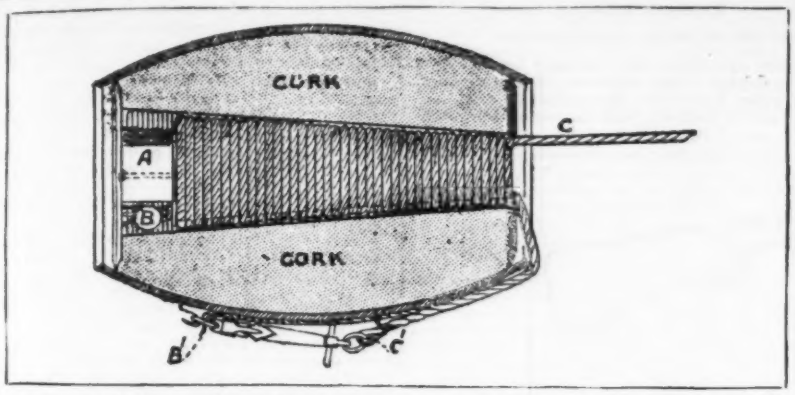
AN ELECTRICAL TORPEDO TO CARRY A CABLE ASHORE. (From a design by Mr. J. Daw, Jr.)



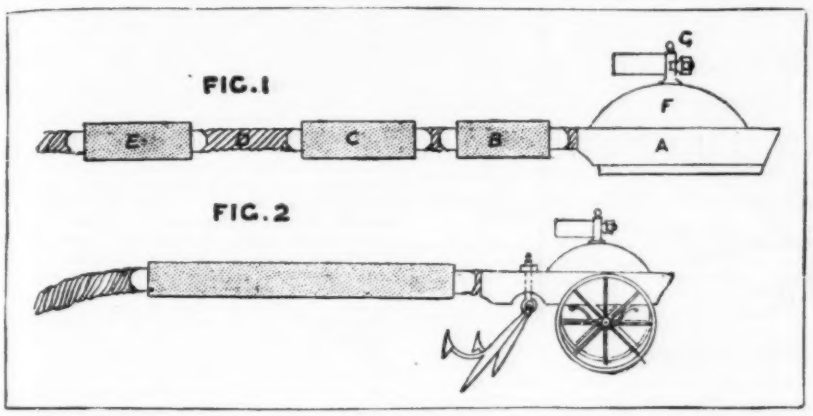
THE "ARK ROPE-LANDER." (From a sketch by Mr. W. F. Dickes.)



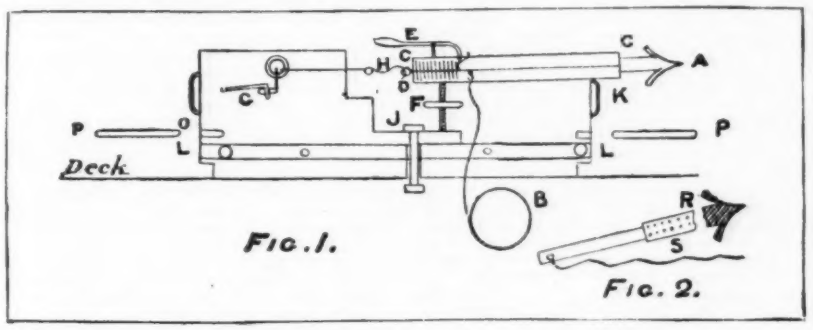
BALL TO CARRY LINE AND GRAPNEL ASHORE.
(From the design of "Evertonian.")



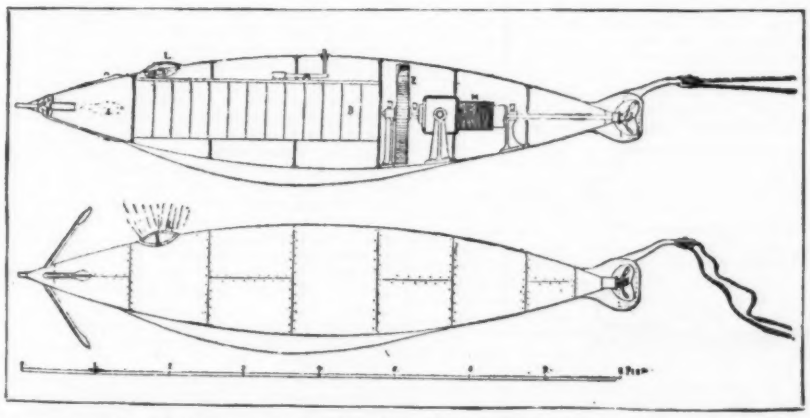
A FLOATING CASK WITH LIFE LINE AND ANCHOR. (From a sketch by Mr. W. Sayer.)



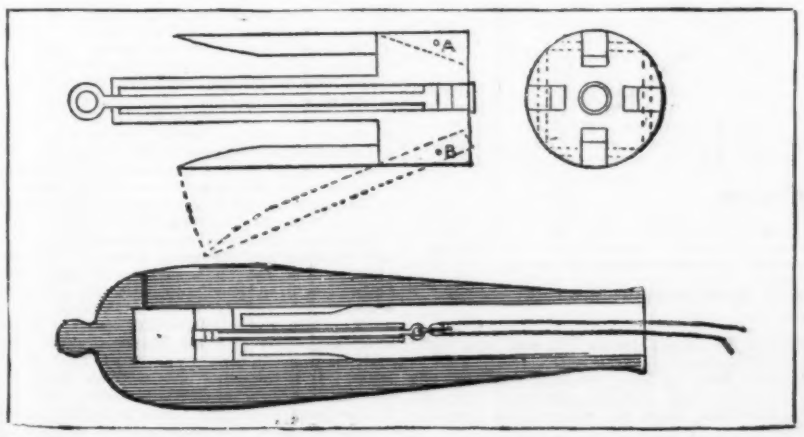
A FLOATING ROPE STIFFENED BY STEEL TUBES. (From sketches by Mr. J. C. Ferguson.)



A LIFE SAVING SPRING GUN. (From a sketch by Mr. F. Stock.)



A TORPEDO WITH GRAPNEL AND DOUBLE LIFE LINE. (Designed by Mr. Albert L. Davis.)



GRAPNEL TO BE FIRED FROM A CANNON. (From a sketch by Mr. J. P. Blurton.)

tween the deck and the floor to form a socket or step for the mast. It would contain a circular man hole provided with a hinged dome, in which would be strong glass windows, and in its upper part four bull's eyes, so that a large lamp placed within may at once light the interior of the boat and at the same time indicate its position to those on the ship. A man could be sent ashore in this dome, and the bottom would have serrated edges so that it might grip the land.

It is pointed out by "Evertonian" that nine out of every ten ships are driven aground on a lee shore, and that what is wanted at the moment is a simple contrivance which will at once get a grapnel on shore. Nothing elaborate, he says, will do. Therefore he suggests the ball, a sketch of which we reproduce. It should be made of India rubber or silk, and, being a sphere in form, could not, he writes, be crushed by the waves, but the moment it was driven on shore the ball would collapse and leave the grapnels—there would be one on each side of the ball—ready to be hauled fast.

The sketch sent us by Mr. W. Sayer represents a cask with most of its interior space filled with cork. The cask, he suggests, should be painted a conspicuous color. The center is to be occupied by a taper sheet iron tube. A large cork float, A, which must be marked with the words "life line," as conspicuously as possible, is placed in the center of the large end of the tube, and a thin line, B, is coiled round and fastened to the float, its other end being fastened to the anchor at B'. The thick line, C, fills the whole remaining portion of the tube, and is to be carefully laid to pay out easily. One end of the line, C, is fastened to the boat anchor at C', which it keeps in its position tight against the outside of the cask till all the line is uncoiled, the other end of the line preserving the connection with the wreck after the cask has been put overboard from the most favorable point.

The invention of Mr. J. C. Ferguson consists of a stout rope, on which are strung lengths of thin steel or iron tubes covered with cork to carry them and the rope. The rope is pushed out from the ship, and each tube sent close up to the one in front, so that "the rope is converted into something like a long pole." Fig. 1 shows the head to the apparatus to be used when assistance is to be had on the shore. A is a boat-shaped log of wood with round top for short flagstaff, G, with lamp in front; B and C, sections of tubes with ends nearly close together; D, rope; E, tube ready to be passed along to next tube, C. Fig. 2 shows the tubes pressed together, and a head piece provided with wheels and anchor for use where no help can be expected from shore.

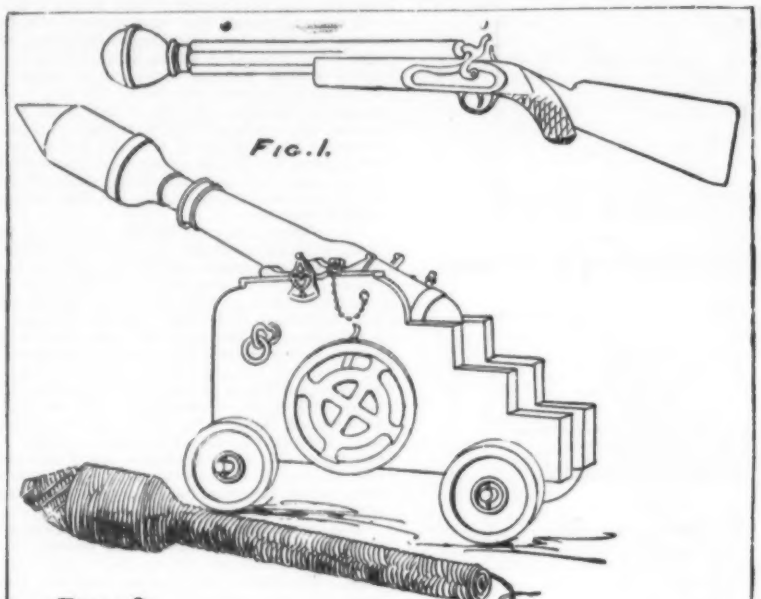
Mr. Frederick Stock sends in a design for a gun which is to be mounted on a turntable on deck. The pivot would be a stout bolt through the deck. The references to the letters will serve to explain the mode of its operation. In Fig. 1, A is the projectile carrying line and blue light; B, life line and coil box; C C, gun; D, spring, compressed; E, firing lever (pressing down handle of which releases spring); F, elevating or depressing screw (the hook at H being first released by unwinding the winder); G, winder with ratchet and safety hook; H, hook from winch attached to breech ring; J, pivot bolt through deck, with screw nut underneath, on which the machine revolves; K, handle for turning the gun on its platform; L, platform with wheel bearings on overlapping rims; O, sockets for small handspikes to assist in turning the gun; P, handspike. Fig. 2 shows the projectile with head, R, unscrewed, and perforated box, S, for blue light.

The next design given is that of a torpedo grapnel, the author of which is Mr. A. L. Davis. The top half of the drawing represents a longitudinal section of the apparatus before striking the shore. The shell is of thin steel and is similar in shape to a Whitehead torpedo. The diameter amidships is about 18 in. and the length over all about 8 ft. 6 in. It is propelled by means of a screw, coupled direct, or by suitable gearing, to an electric motor, which makes 1,200 to 1,500 revolutions a minute. F is a heavy fly wheel fixed to the motor shaft, and is about 16 in. in diameter. "This fly wheel plays a very important part, and it is by means of the powerful 'gyroscopic' action which it sets up that the apparatus travels in a straight line." The motor receives its energy from thirteen or more large chromic acid batteries, such as at B, each cell containing four carbon and three zinc plates, each about 9 in. square and ¼ in. thick. When not in use the acid solution is not in contact with the battery plates. To start the apparatus it is only necessary to strike the valve rod, V, when the solution at once enters the batteries and the motor immediately starts. There is sufficient acid solution and zinc to maintain full speed for nearly two hours. On striking the shore, the steel arms, A, fly out at an angle as shown in the lower sketch, thus forming a grapnel which secures the line in the event of no one being on the spot to receive it. On striking the shore the current is automatically switched on to the connections of a low voltage lamp, L, which serves to show the place of the torpedo at night.

The suggestion which Mr. J. P. Blurton makes is that of a grapnel of peculiar construction to be fired from a small cannon, such as is used for signaling. The sketches show the grapnel in longitudinal section, a cross section of the grapnel head, and a section of the cannon with the grapnel in position for firing. The flukes would be movable about the pivots at A B, so that by their weight they would come into the position shown by the dotted line in the sketch of the longitudinal section. The shank as shown in the sketch may be lengthened by a telescopic arrangement, so as to insure the flukes holding. To the eye, C, a small pulley is attached through which a light rope is threaded until there are equal lengths on both sides, and the rope is coiled so as to run smoothly. The grapnel is fired ashore, and by means of the rope a man can be sent to land in a life belt, who can then haul ashore a strong cable. The end, C, is toward the mouth of the cannon when in position for firing, and the weight of the grapnel would be about 3¼ lb.

The guns patented by Mr. D. R. Dawson are called "line-throwing guns." In the sketches, Fig. 1 shows such a gun for the shoulder and the other a 3½ in. ship's deck gun. The shoulder gun has a range of 150 yards, and the deck gun of 400 yards. These guns discharge a canister containing a "cop" of line. The gun, as we understand it, has an interior tube, and the cop

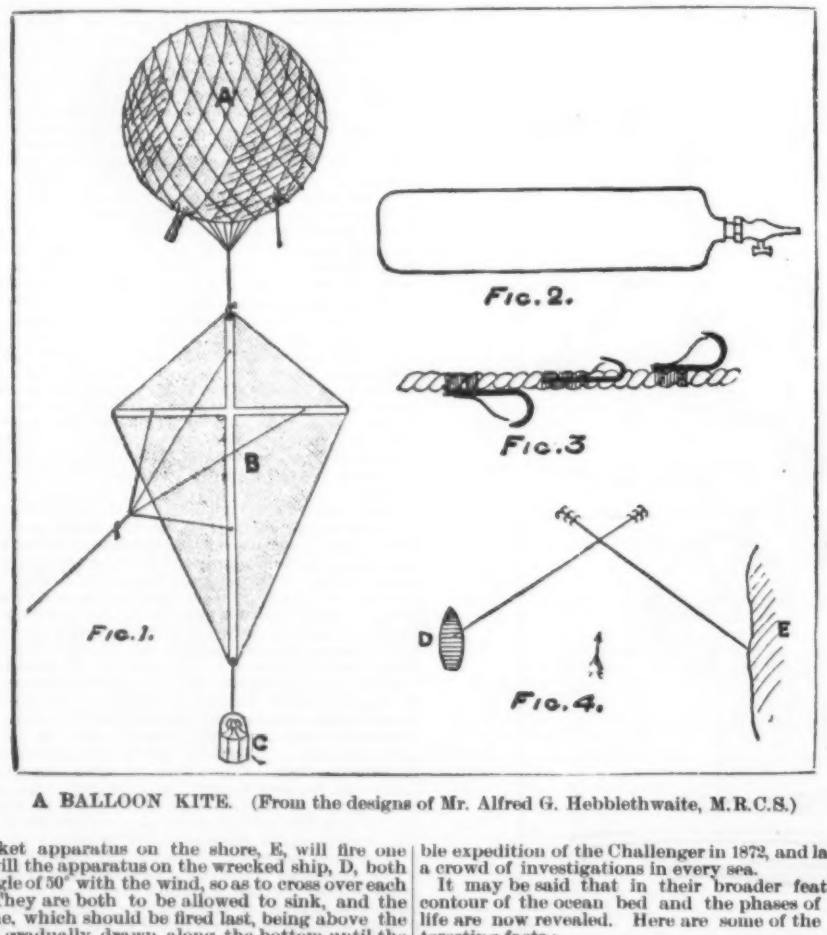
a corresponding hollow extending through its entire length, and the canister has a hole in the end. When placed in the gun, the tube passes up through both canister and cop, and when the gun is discharged the canister or projectile pays out the line as it flies. The powder charge is contained in a gas check outside the tube. The line is made fast to the gun stock at one



LINE-THROWING GUNS (From designs by Mr. D. R. Dawson.)

end and the other passes through the top of the canister.

Mr. Hebblethwaite's invention includes both the kite and the balloon. It consists of an iron cylinder (Fig. 2), containing highly compressed hydrogen gas, an India rubber balloon inclosed in a netting of string (A, Fig. 1), a kite (B, Fig. 1) with ballast (C, Fig. 1) below, to be attached below the balloon, and a fuse, shown in Fig. 1, depending from the right side of the balloon, leading to an explosive (the fuse timed), and a large supply of light, strong rope. In event of wreck, the balloon is to be distended by means of the hydrogen through the muzzle on the left side of the balloon, which is then, with its appendages, let go. The fuse is timed to cover the distance to the shore. When over the land the explosive is to burst, and the kite to fall, communication being thus established, supposing any one is there to receive the line. In Figs. 3 and 4 are illustrated another suggestion by Mr. Hebblethwaite. Fig. 3 is a rocket cord with large hook along its distal end, pointing in different directions. These are to be used as shown in Fig. 4 in the event of the wind blowing directly across between the vessel and the shore.



A BALLOON KITE. (From the designs of Mr. Alfred G. Hebblethwaite, M.R.C.S.)

The rocket apparatus on the shore, E, will fire one line, so will the apparatus on the wrecked ship, D, both at an angle of 50° with the wind, so as to cross over each other. They are both to be allowed to sink, and the shore line, which should be fired last, being above the other, is gradually drawn along the bottom until the hooks become fixed in those of the line from the ship.

THE OCEAN.

RESULTS OF DEEP SEA RESEARCH.

A FEW years ago when the steamer Gazelle was dredging the depths of the Southern Atlantic, many hundreds of miles from land, the scientific staff was greatly surprised to haul up from the sea bottom many grains of quartz. These heavy deposits could not have been carried from the land, for the ship was far north of the track of the Antarctic icebergs. It was believed this quartz in the middle of the ocean might afford another proof that igneous or eruptive rocks, now and then, are thrust by subterranean action up through the deposits on the ocean bottom. Another explanation of these quartz finds was advanced. Suppose a ship with sand ballast was lost in the middle of the ocean. In that event its millions of quartz grains would be sifted over the sea bottom; which goes to show that scientific men cannot always, with safety, attribute to mighty phenomena their accidental finds.

The world is now taking wonderful interest in deep sea exploration. Many vessels are engaged in this work. The science of oceanography is still young, and, strangely enough, it was not naturalists but engineers who first began to explore the ocean depths. It was when the first submarine cable between Europe and America was laid that the scientific world turned its attention to the study of the ocean abysms. The English vessel Porcupine, in 1869, fairly ushered in the era of deep sea research. Then followed the memorable expedition of the Challenger in 1872, and later came a crowd of investigations in every sea.

It may be said that in their broader features the contour of the ocean bed and the phases of deep sea life are now revealed. Here are some of the most interesting facts:

It was supposed a few years ago that the ocean bottom was largely a counterpart of the land features of the globe, with its mighty mountain ranges pushing up toward the surface of the sea, and deep valleys and glens sinking to almost unfathomable depths. This is found to be true only to a limited extent. Here and there, to be sure, mighty mountains push toward the surface or rise above it, forming islands, and then, again, the bottom sinks in a narrow trough, as off the northeast coast of Japan, until it seems as though the sounding line could never measure its depth. But the ocean bed, in the main, is found gently to undulate, and would appear, if it could be observed, as of a slightly rolling plain.

It has been found also that we used to have very exaggerated views of ocean depths. Maury, in his day the great authority upon the ocean, popularized the idea that a depth of eight or nine miles might be found in midocean. We know now that a depth of five miles is very exceptional. General Von Tillo, who has made the latest determinations of ocean depths, fixes the mean depth of all the oceans at 3,808 meters, or about 12,700 ft., less than two and a half miles. The Pacific Ocean averages about 1,100 ft. deeper than the Atlantic. The North Atlantic is deeper than the South Atlantic, and the Arctic Ocean grows shallower the nearer the pole is approached.

Very interesting facts have been discovered with regard to the great distances from land at which the sediment brought down by mighty rivers is spread over the sea bottom. Those giants among rivers, the Niger and the Congo, produce most marked effects upon the nature of the deposits at the bottom of the ocean. Buchanan has found that the sea bed for hundreds of miles from land, from the Gulf of Guinea to Loanda, has been filled up to an enormous extent by the dark colored soft muds brought down by the rivers; and off the mouth of the Congo the shore mud has been traced to a depth of 18,000 ft. at a distance of 600 miles from land. In the Bay of Bengal and the Arabian Sea the sediment from the Indus and the Ganges is spread out over the greater extent of the ocean's floor. Antarctic ice brings as far north as 40° south latitude the debris from lands perhaps still unknown. Dr. Murray says, however, that toward the central parts of the oceans it is difficult to trace the ordinary river detritus in the deposits there forming.

Before the Challenger expedition only six deep-sea fishes were known. To-day about ten times as many forms of deep-sea life are familiar to oceanographers. We can form some idea of the abundance of life existing in some regions at a depth of two and a half miles, when it is said that at a single haul of the trawl only twelve feet wide, and dragged over the bottom for a very short distance, as many as 150 specimens of the higher forms of deep-sea life have been obtained.

One very interesting fact seems to have been established by the recent investigations in the Pacific of our fish commission steamer Albatross. It has long been known that the group of animals characteristic of the upper part of oceanic waters is entirely distinct from the forms of life near and at the bottom of the sea. The Challenger investigators thought they had established the fact that another distinct group of animals exists in the intermediate depths between these upper and lower forms of life. This theory seems to have been upset by the work of the Albatross. The naturalists of this vessel have found that the forms of sea life in the upper portion of the ocean waters may descend to a depth of 1,200 feet or so from the surface, but there then succeeds a barren zone which continues to within 360 to 300 ft. from the bottom, where the deep-sea animals begin to appear.

As a rule, these deep-sea animals have no eyes, showing that they have no need of them. The fact that they are subjected to enormous pressure is shown by many of them bursting open when brought to the surface. Some of them have very bright colors, and they are found most abundantly along the courses of the great currents, showing that these rivers in the ocean bring a large amount of food for the deep-sea fauna.

A narrative of the minor and curious incidents of deep-sea exploration would make an interesting story. It was a distressing though rather ludicrous mishap that befell Dr. Hansen, who unfortunately wrote his labels and description of the sponges collected by the Norwegian North Atlantic expedition in fugitive ink, and the records of his work became indecipherable. One thermometer now in use registers the temperature at any desired depth by means of a weight which is sent down the line to the depth required, and striking the thermometer, inverts it. A while ago a small flat fish was investigating the instrument at a depth of 1,200 ft., when the weight descended and caught the animal. From the standpoint of a deep-sea fish it seems hard that an animal living so far from the resources of civilization should be exposed to accidents by machinery.

An enormous extent of territory was covered by the Albatross in her various cruises along the Pacific coast of the Americas. In Alaskan waters she has traced the limits of great fishing banks where some day thousands of Americans may find profitable employment. Her series of soundings has extended for thousands of miles along the coast. In the neighborhood of the isthmus she has found that the animal life of the Pacific compares but poorly with that of the Caribbean Sea, but many of the species on both sides of the isthmus are identical. We observe that the most extended work in recent years has been done by the Albatross; by the Egeria, which has made many hundreds of soundings between Australia, New Zealand, and the Phœnix Islands north of Samoa, covering the western Pacific with a network of observations; by the Dolphin and Seine, both of which have stretched a series of soundings across the Atlantic; and by the Investigator, in the North Indian Ocean.

These expeditions have demonstrated the interesting fact that the knowledge of deep-sea deposits has now advanced so far that experts at home, from the examination of a specimen, can tell approximately at what depth and in what latitude it was taken, and with certain reservations can roughly determine the longitude. To give an illustration or two—in tropical regions distant from land and at a depth of 18,000 ft. the deposit seems without exception to be a clay arising from the decomposition of volcanic matter. In the greatest depths there is hardly a trace of carbonate of lime, but at depths of 12,000 ft. more than half of the deposits consist of this deposit. Within 100

to 150 miles of land all the pelagic organisms are more or less completely hidden by the large amount of coast or river debris with which they are mixed.

One vessel, the Dolphin, found a depth of 20,646 ft. south of the Azores, which was the greatest depth discovered during its long cruise. The Seine discovered that the now famous Trinidad depression (over 20,000 ft.) was not so extensive as it is represented on the maps. The Pola's investigations in the Eastern Mediterranean resulted in recording the depth of 13,516 ft., the greatest depth yet found there, and the great depression in this sea must therefore be moved quite a way east from its former central position on the maps. The Black Sea has been gridironed by lines of soundings, and the important fact has been discovered that below 600 ft. there is no organic life, the lower stratum of water being so much impregnated with sulphureted hydrogen. An important series of soundings between the Bermuda Islands and Nova Scotia was made when the Westmeath laid the cable that now connects Bermuda with the rest of the world. The work of the Fylla in Denmark Strait, between Greenland and Iceland, had the important result of showing that the warmer Atlantic waters pass north through the strait under the surface polar stream flowing south.

The oceanic studies referred to here are only a small part of the work of these expeditions. They have been rich in results concerning the nature and extent of the currents, the color and transparency of sea water, the temperature at various depths, polar ice, the formation and dimensions of waves, and various other phenomena; and the extensive literature now accessible, relating to the sea in all its aspects, shows that rapid progress is making in oceanography, the youngest of the sciences. —*New York Sun.*

THE SQUARING OF THE CIRCLE.

AN HISTORICAL SKETCH OF THE PROBLEM FROM THE EARLIEST TIMES TO THE PRESENT DAY.*

By HERMANN SCHUBERT.

I.—UNIVERSAL INTEREST IN THE PROBLEM.

FOR two and a half thousand years both trained and untrained minds have striven in vain to solve the problem known as the squaring of the circle. Now that geometers have at last succeeded in giving a rigid demonstration of the impossibility of solving the problem with ruler and compasses, it seems fitting and opportune to cast a glance into the nature and history of this very ancient problem. And this will be found all the more justifiable in view of the fact that the squaring of the circle, at least in name, is very widely known outside of the narrow limits of professional mathematicians.

The Resolution of the French Academy.—The proceedings of the French Academy for the year 1775 contain, at page 61, the resolution of the academy not to examine, from that time on, any so-called solutions of the quadrature of the circle that might be handed in. The academy was driven to this determination by the overwhelming multitude of professed solutions of the famous problem, which were sent to it every month in the year—solutions which, of course, were an invariable attestation of the ignorance and self-consciousness of their authors, but which suffered collectively from a very important error in mathematics; they were *wrong*. Since that time all professed solutions of the problem received by the academy find a sure haven in the waste basket, and remain unanswered for all time. The circle squarer, however, sees in this high-handed manner of rejection only the envy of the great toward his grand intellectual discovery. He is determined to meet with recognition, and appeals, therefore, to the public. The newspapers must obtain for him the appreciation that scientific societies have denied. And every year the old mathematical sea serpent more than once disports itself in the columns of our papers, that a Mr. N. N., of P. P., has at last solved the problem of the quadrature of the circle.

General Ignorance of Quadrators.—But what kind of people are these circle squarers, when examined by the light? Almost always they will be found to be imperfectly educated persons, whose mathematical knowledge does not exceed that of a modern college freshman. It is seldom that they know accurately what the requirements of the problem are and what its nature. They never know the two and a half thousand years' history of the problem, and they have no idea whatever of the important investigations and results which have been made with reference to the problem by great and real mathematicians in every century down to our time.

A Cyclometric Type.—Yet great as is the quantum of ignorance that circle squarers intermix with their intellectual products, the lavish supply of conceit and self-consciousness with which they season their performances is still greater. I have not far to go to furnish a verification of this. A book printed in Hamburg in the year 1840 lies before me, in which the author thanks Almighty God at every second page that he has selected him and no one else to solve the "problem phenomenal" of mathematics, "so long sought for, so fervently desired, and attempted by millions." After the modest author has proclaimed himself the unmasker of Archimedes' deceit, he says: "It thus has pleased Mother Nature to withhold this mathematical jewel from the eye of human investigation until she thought it fitting to reveal Truth to Simplicity."

This will suffice to show the great self-consciousness of the author. But it does not suffice to prove his ignorance. He has no conception of mathematical demonstration; he takes it for granted that these things are so because they seem so to him. Errors of logic, also, are abundantly found in his book. But apart from this general incorrectness, let us see wherein the real gist of his fallacy consists. It requires considerable labor to find out what this is from the turgid language and bombastic style in which the author has buried his conclusions. But it is this: The author inscribes a square in a circle, circumscribes another about it, then points out that the inside square is made up of four congruent triangles, whereas the circumscribed square is made up of eight such triangles; from which fact, seeing that the circle is larger than the one square and smaller than the other, he draws the bold conclusion that the circle is equal in area to six such triangles. It is hardly conceivable that a rational being could infer that something which is greater than 4 and less than 8 must necessarily be 6. But with a man that attempts the squaring of the circle this kind of ratiocination *is* possible.

Similarly in the case of all other attempted solutions of the problem, either logical fallacies or violations of elementary arithmetical or geometrical truths may be pointed out. Only they are not always of such a trivial nature as in the book just mentioned.

Let us now inquire whence the inclination arises which leads people to take up the quadrature of the circle and to attempt to solve it.

The Allurements of the Problem.—Attention must first be called to the antiquity of the problem. A quadrature was attempted in Egypt 500 years before the exodus of the Israelites. Among the Greeks the problem never ceased to play a part that greatly influenced the progress of mathematics. And in the middle ages also the squaring of the circle sporadically appears as the philosopher's stone of mathematics. The problem has thus never ceased to be dealt with and considered. But it is not by the antiquity of the problem that circle squarers are enticed, but by the allurement which everything exerts that is calculated to raise the individual out of the mass of ordinary humanity, and to bind about his temples the laurel crown of celebrity. It is ambition that spurred men on in ancient Greece and still spurs them on in modern times to crack this primeval mathematical nut. Whether they are competent thereto is a secondary consideration. They look upon the squaring of the circle as the grand prize of a lottery that can just as well fall to their lot as to that of any other. They do not remember that—

> Toil before honor is placed by sagacious decrees of immortals,

and that it requires years of continued studies to gain possession of the mathematical weapons that are indispensably necessary to attack the problem, but which even in the hands of the most distinguished mathematical strategists have not sufficed to take the stronghold.

About the Only Problem Known to the Lay World.—But how is it, we must further ask, that it happens to be the squaring of the circle, and not some other unsolved mathematical problem, upon which the efforts of people are bestowed who have no knowledge of mathematics, yet busy themselves with mathematical questions? The question is answered by the fact that the squaring of the circle is about the only mathematical problem that is known to the unprofessional world —at least by name. Even among the Greeks the problem was very widely known outside of mathematical circles. In the eyes of the Grecian layman, as at present among many of his modern brethren, occupation with this problem was regarded as the most important and essential business of mathematicians. In fact they had a special word to designate this species of activity, namely, τετραγωνίζειν, which means to busy one's self with the quadrature. In modern times, also, every educated person, though he be not a mathematician, knows the problem by name, and knows that it is insolvable, or at least, that despite the efforts of the most famous mathematicians it has not yet been solved. For this reason the phrase "to square the circle" is now used in the sense of attempting the impossible.

Belief that Rewards have been Offered.—But in addition to the antiquity of the problem, and the fact also that it is known to the lay world, we have yet a third factor to point out that induces people to take up with it. This is the report that has been spread for a hundred years now, that the academies, the Queen of England, or some other influential person, has offered a great prize to be given to the one that first solves the problem. As a matter of fact we find the hope of obtaining this large prize of money the principal incitement to action with many circle squarers. And the author of the book above referred to begs his readers to lend him their assistance in obtaining the prizes offered.

The Problem among Mathematicians.—Although the opinion is widely current in the unprofessional world that professional mathematicians are still busied with the solution of the problem, this is by no means the case. On the contrary, for some two hundred years, the endeavors of many considerable mathematicians have been solely directed toward demonstrating with exactness that the problem is insolvable. It is, as a rule—and naturally—more difficult to prove that something is impossible than to prove that it is possible. And thus it has happened that up to within a few years ago, despite the employment of the most varied and the most comprehensive methods of modern mathematics, no one succeeded in supplying the wished-for demonstration of the problem's impossibility. At last, Professor Lindemann, of Konigsberg, in June, 1882, succeeded in furnishing a demonstration—and the first demonstration—that it is impossible by the exclusive employment of ruler and compasses to construct a square that is mathematically exactly equal in area to a given circle. The demonstration, naturally, was not effected with the help of the old elementary methods; for if it were, it would surely have been accomplished centuries ago; but methods were requisite that were first furnished by the theory of definite integrals and departments of higher algebra developed in the last decades; in other words, it required the direct and indirect preparatory labor of many centuries to make finally possible a demonstration of the insolvability of this historic problem.

Of course, this demonstration will have no more effect than the resolution of the Paris Academy of 1775 in causing the fecund race of circle squarers to vanish from the face of the earth. In the future, as in the past, there will be people who know nothing and will not want to know anything of this demonstration, and who believe that they cannot help but succeed in a matter in which others have failed, and that just they have been appointed by Providence to solve the famous puzzle. But unfortunately the ineradicable passion of wanting to solve the quadrature of the circle has also its serious side. Circle squarers are not always so self-contented as the author of the book we have mentioned. They often see or at least divine the insuperable difficulties that tower up before them, and the conflict between their aspirations and their performances, the consciousness that they want to solve the problem but are unable to solve it, darkens their soul, and, lost to the world, they become interesting subjects for the science of psychiatry.

II.—NATURE OF THE PROBLEM.

Numerical Rectification.—If we have a circle before us, it is easy for us to determine the length of its radius or of its diameter, which must be double that of the radius; and the question next arises to find the number that represents how many times larger its circumference, that is the length of the circular line, is than its radius or its diameter. From the fact that all circles have the same shape, it follows that this proportion will always be the same for both large and small circles. Now since the time of Archimedes, all civilized nations that have cultivated mathematics have called the number that denotes how many times larger than the diameter the circumference of a circle is, π— the Greek initial letter of the word periphery. To compute π, therefore, means to calculate how many times larger the circumference of a circle is than its diameter. This calculation is called "the numerical rectification of the circle."

The Numerical Quadrature.—Next to the calculation of the circumference, the calculation of the superficial contents of a circle by means of its radius or diameter is perhaps most important; that is the computation of how much area that part of a plane which lies within a circle measures. This calculation is called the "numerical quadrature." It depends, however, upon the problem of numerical rectification; that is, upon the calculation of the magnitude of π. For it is demonstrated in elementary geometry that the area of a circle is equal to the area of a triangle produced by drawing in the circle a radius, erecting at the extremity of the same a tangent —that is, in this case a perpendicular—cutting off upon the latter the length of the circumference, measuring from the extremity, and joining the point thus obtained with the center of the circle. But it follows from this that the area of a circle is as many times larger than the square upon its radius as the number π amounts to.

Constructive Rectification and Quadrature.—The numerical rectification and numerical quadrature of the circle based upon the computation of the number π are to be clearly distinguished from problems that require a straight line equal in length to the circumference of a circle, or a square equal in area to a circle, to be *constructively* produced out of its radius or its diameter; problems which might properly be called "constructive rectification" or "constructive quadrature." Approximately, of course, by employing an approximate value for π these problems are easily solvable. But to solve a problem of construction, in geometry, means to solve it with mathematical exactitude. If the value π were exactly equal to the ratio of two whole numbers to one another, the constructive rectification would present no difficulties. For example, suppose the circumference of a circle were exactly 3½ times greater than its diameter; then the diameter could be divided into seven equal parts, which could be easily done by the principles of planimetry with ruler and compasses; then we would produce to the amount of such a part a straight line exactly three times larger than the diameter, and should thus obtain a straight line exactly equal to the circumference of the circle. But as a matter of fact, and as has actually been demonstrated, there do not exist two whole numbers, be they ever so great, that exactly represent by their proportion to one another the number π. Consequently, a rectification of the kind just described does not attain the object desired.

It might be asked here, whether from the demonstrated fact that the number π is not equal to the ratio of two whole numbers, however great, it does not immediately follow that it is impossible to construct a straight line exactly equal in length to the circumference of a circle; thus demonstrating at once the impossibility of solving the problem. This question is to be answered in the negative. For there are in geometry many sets of two lines of which the one can be easily constructed from the other, notwithstanding the fact that no two whole numbers can be found to represent the ratio of the two lines. The side and the diagonal of a square, for instance, are so constituted. It is true the ratio of the latter two magnitudes is nearly that of 5 to 7. But this proportion is not exact, and there are, in fact, no two numbers that represent the ratio exactly. Nevertheless, either of these two lines can be easily constructed from the other by the sole employment of ruler and compasses. This might be the case, too, with the rectification of the circle; and consequently from the impossibility of representing π by the ratio between two whole numbers, the impossibility of the problem of rectification is not inferable.

The quadrature of the circle stands and falls with the problem of rectification. This is based upon the truth above mentioned, that a circle is equal in area to a right angle triangle, in which one side is equal to the radius of the circle and the other to the circumference. Supposing accordingly that the circumference of the circle were rectified, then we could construct this triangle. But every triangle, as is taught in the elements of planimetry, can with the help of ruler and compasses be converted into a square exactly equal to it in area. So that, therefore, supposing the rectification of the circumference of a circle were successfully performed, a square could be constructed that would be exactly equal in area to the circle.

The dependence upon one another of the three problems of the computation of the number π, of the quadrature of the circle, and its rectification, thus obliges us, in dealing with the history of the quadrature, to regard investigations with respect to the value of π and attempts to rectify the circle as of equal importance, and to consider them accordingly.

Conditions of the Geometrical Solution.—We have used repeatedly in the course of the discussion the expression "to construct with ruler and compasses." It will be necessary to explain what is meant by the specification of these two instruments. When such a number of conditions is annexed to a requirement in geometry to construct a certain figure that the construction only of *one* figure or a limited number of figures is possible in accordance with the conditions given, such a complete requirement is called a problem of construction, or briefly a problem. When a prob-

* From Holtzendorff and Virchow's *Sammlung gemeinverstandlicher wissenschaftlicher Vortrage*. Heft 67. Hamburg: Verlagsanstalt, etc. Reprinted from *The Monist*, January, 1891, vol. 1, No. 2, pp. 197-228.—*Smithsonian Report*, 1890.

lem of this kind is presented for solution it is necessary to reduce it to simpler problems, already recognized as solvable; and since these latter depend in their turn upon other still simpler problems, we are finally brought back to certain fundamental problems, upon which the rest are based but which are not themselves reducible to problems less simple. These fundamental problems are, so to speak, the undermost stones of the edifice of geometrical construction. The question next arises as to what problems may be properly regarded as fundamental; and it has been found that the solution of a great part of the problems that arise in elementary planimetry rests upon the solution of only five original problems. They are:

(1) The construction of a straight line which shall pass through two given points.

(2) The construction of a circle the center of which is a given point and the radius of which has a given length.

(3) The determination of the point that lies coincidently on two given straight lines extended as far as is necessary—in case such a point (point of intersection) exists.

(4) The determination of the two points that lie coincidently on a given straight line and a given circle—in case such common points (points of intersection) exist.

(5) The determination of the two points that lie coincidently on two given circles—in case such common points (points of intersection) exist.

For the solution of the last three of these five problems the eye alone is needed, while for the solution of the first two problems, besides pencil, ink, chalk, and the like, additional special instruments are required; for the solution of the first problem a ruler is most generally used, and for the solution of the second a pair of compasses. But it must be remembered that it is no concern of geometry what mechanical instruments are employed in the solution of the five problems mentioned. Geometry simply limits itself to the presupposition that these problems are solvable, and regards a complicated problem as solved if, upon a specification of the constructions of which the solution consists, no other requirements are demanded than the five above mentioned. Since, accordingly, geometry does not itself furnish the solution of these five problems, but rather exacts them, they are termed *postulates.** All problems of planimetry are not reducible to these five problems alone. There are problems that can be solved only by assuming other problems as solvable which are not included in the five given; for example, the construction of an ellipse, having given its center and its major and minor axes. Many problems, however, possess the property of being solvable with the assistance solely of the five postulates above formulated, and where this is the case they are said to be "constructible with ruler and compasses," or "elementarily" constructible.

After these general remarks upon the solvability of problems of geometrical construction, which an understanding of the history of squaring of the circle makes indispensably necessary, the significance of the question whether the quadrature of the circle is or is not solvable, that is, elementarily solvable, will become intelligible. But the conception just discussed of elementary solvability only gradually took clear form, and we therefore find among the Greeks as well as among the Arabs, endeavors, successful in some respects, that aimed at solving the quadrature of the circle with other expedients than the five postulates. We have also to take these endeavors into consideration, and especially so as they, no less than the unsuccessful efforts at elementary solution, have upon the whole advanced the science of geometry and contributed much to the clarification of geometrical ideas.

(To be continued.)

* Usually geometers mention only two postulates (Nos. 1 and 2). But since to geometry proper it is indifferent whether only the eye or additional special mechanical instruments are necessary, the author has regarded it more correct in point of method to assume five postulates.

EXPERIMENTS IN CAPILLARITY.

UP to recent years, it has been customary to consider capillary phenomena as difficult to understand, and, upon the whole, as of but a moderate importance; but now there is a movement making in their favor. The diversity of action of these mysterious forces, their participation in the majority of the natural phenomena, the remote conclusions to which they lead, and the brilliant experiments to which they give rise begin to obtain for them a little more than the esteem of persons friendly to physics. We have no intention of recalling the memorable facts that have been developed in this science, since the great Laplace, following Newton, has laid down the solid bases of them. Experiments relative to capillarity have been numerous in all countries, but the true experimental direction of modern researches was given by Plateau, whose beautiful experiments, completed by Mr. Van der Mensbrugghe, form to-day a compact and well ordered whole. In England, those masters of physics, Sir William Thomson and Lord Rayleigh, have taken hold of it, and while enriching it, have marked it with the seal of practical sense of the Anglo-Saxon race. They have formed a school in the country of the English language in which the experiments of Messrs. Reinhold and Rucker and the quasi-industrial applications of Mr. Chichester Bell give proof of it. In the hands of one of the youngest of the members of the Royal Society, Mr. C. V. Boys, the results obtained, completed and introduced into courses of lectures, have been the subject of lectures at the Royal Institution. These, collected into a volume, under the title of "Soap Bubbles," offer so rich a harvest of little known facts that they have appeared worthy of being propagated in France.

A translation of this little work on entertaining science will appear before long. We shall select from it a few experiments that have seemed to us particularly attractive.

We shall begin by describing an experiment which is sure of success without much preparation. Afterward, we shall seek the theory of it. Let us fix a glass tube, terminating in an orifice 1 or 2 mm. in diameter, to the extremity of a rubber tube; then, after putting the tube in communication with a water pipe, let us open the cock so as to produce an ascending stream about one meter in height (Fig. 1). A well known phenomenon will occur: At a slight distance from the orifice the stream will be resolved into drops of various sizes, which will scatter over a wide space, and, in falling upon a sheet of paper, will produce a dull and continuous sound. If now we place a stick of electrified sealing wax near the stream, the aspect will be immediately modified. The stream will contract and form into large drops which will follow the same course (Fig. 2). The sound that they will make in falling upon the paper will imitate the rain of a thunderstorm, to which, as to result and secondary cause, one cannot help comparing them.

An analogous effect is obtained by resting a stick of wood, on the one hand, upon the glass tube, and, on the other, upon the sounding box of a tuning fork kept in vibration. On managing properly, it is possible even, in this case, to obtain several distinct jets of large drops.

We have promised to explain these singular phenomena. The thing is not difficult, but it is necessary

FIGS. 1 AND 2.

1. Jet of water composed of dispersed drops. 2. The same condensed into large drops by electricity.

to take up the theory from a somewhat elevated standpoint. As we proceed we shall, however, meet with other experiments, none the less curious, that will give respite to our readers from a reasoning in which it would be difficult to avoid prolixity. In a former article we stated that the air inclosed in a soap bubble is submitted to a pressure which depends upon the curve of the bubble. This is easily shown. If we blow two spherical bubbles of different sizes at the two free extremities of an H-shaped tube, the smaller one will empty itself into the larger.

By interposing cocks in the branches of the H, it is possible to arrest the bubbles at a certain size, and then to take them up opposite the orifice of the tubes by means of two rings of the same diameter, and to draw them out by lifting the tube. In this way we obtain bubbles which assume in succession the form of a barrel and a cylinder. Fig. 3 (Nos. 1 and 2) shows the arrangement of the experiment. The bubble to the left is already empty, while the one to the right, the larger in the beginning, is still swollen, and will finally empty itself upon becoming elongated. If, now, we open the cocks so as to put the bubbles in communication through the tube, one of them will usually drive the air into the other. Now this is what we observe: If the bubbles have the same diameter and length, and one be rounded and the other constricted, the first will send air into the second, if their length is less than half their circumference at the point of junction with the tube. The opposite occurs when the length exceeds half the circumference. Fig. 3 (Nos. 1 and 2, in which the arrows show the direction of the air's motion) will allow this phenomenon to be understood.

Now, an isolated cylindrical bubble closed at its extremities, and the length of which exceeds the half circumference, while remaining less than the entire circumference, may be regarded as the whole of two bubbles of the first species placed end to end. If the length exceeds the circumference, the two cylindrical bubbles figured are of the second species. If, then, for any cause whatever, the cylinder undergoes a distortion, becoming constricted at one end and inflated at the other, an equilibrium will be re-established in the first bubble, and will be completely destroyed in the second, which, in an instant, will separate into two unequal bubbles (Fig. 3, No. 3).

The same thing occurs in a liquid issuing from a circular orifice. During a part of its course it may be considered as the union of cylinders placed end to end, and in which the least distortion will tend to become pronounced through the effect of the superficial film of water acting upon the interior liquid, just as the film of soap water compresses the air that it contains. The least inequalities of the jet increase with extreme rapidity. For example, Lord Rayleigh has demonstrated that if a depression is made in a stream of water one millimeter in diameter, the latter will become a thousand times stronger in a fortieth of a second. Now, the best fitted tube always undergoes slight vibrations which are communicated to the stream and become themselves pronounced.

Under ordinary circumstances, the impulses that the stream receives in the beginning are very irregular and cause the bursting of a large number of unequal cylinders, which contract into drops. At the moment that a drop is about to separate, it is held by the neck that connects it with the following one still in process of formation. Each one draws from its own side, and the velocity of each drop is a resultant of these various actions. It is evident, therefore, that the drops start sensibly in the same direction, but with different velocities. They take various trajectories at the outset, and come into collision obliquely. Now, under ordinary circumstances, two drops coming into contact do not unite, but rebound from each other. It is difficult to demonstrate this directly upon drops of water, but nothing is easier than to perform the experiment either with soap bubbles or with jets of water, as Lord Rayleigh has done for the first time. Two streams of a liquid, one of which has been colored with aniline, are made to reach each other at an acute angle.

They will rebound, and no trace of color will pass from one to the other, thus showing that they have not come into real contact. But if an electric field be produced by simply holding an electrified stick of sealing wax at a few meters from the apparatus, the two streams will immediately unite. The same phenomenon is produced with the drops of water which collide, and which unite when they are electrified, doubtless because poles of contrary names are opposite each other and the electric attraction suffices to force the drops to come into contact. Mr. Boys has repeated this experiment with two soap bubbles, which, suspended from metallic rings, and placed against each other, do not unite until they are submitted to electric action. They form an electroscope of extreme sensitiveness.

The rest of the preceding experiment will be understood of itself. The drops which, in colliding in slightly different directions, rebound in spreading, unite, on the contrary, and take an intermediate course.

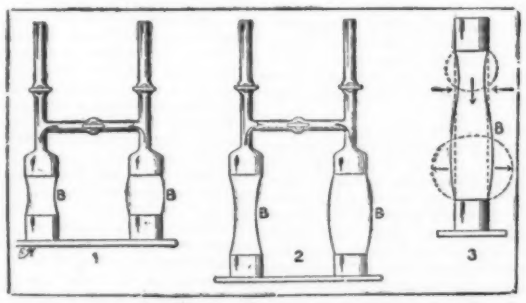


FIG. 3.—EXPERIMENT ON SOAP BUBBLES.

1 and 2. Soap bubbles, one emptying into the other. 3. Unstable cylindrical bubble. The bubbles are figured B B B B B.

The tuning fork experiment thus becomes easily explicable. From the moment that a regular vibration is communicated to the orifice, the depressions succeed each other upon the jet at equal intervals, the drops of the same size follow the same track with the same velocity, and the cause of their dispersion has disappeared.

It may also happen that the tuning fork communicates to the orifice a complex vibration composed, for example, of two unequally spaced shocks. The stream then breaks up into two series of drops, alternately large and small, and there is produced between the two systems the actions that manifest themselves irregularly between the drops of any stream. The result is that the two series soon separate, the drops rebound two by two at the same place, and we see two strings of drops, which for an instant appear to form two continuous lines, as if the tube had two orifices.

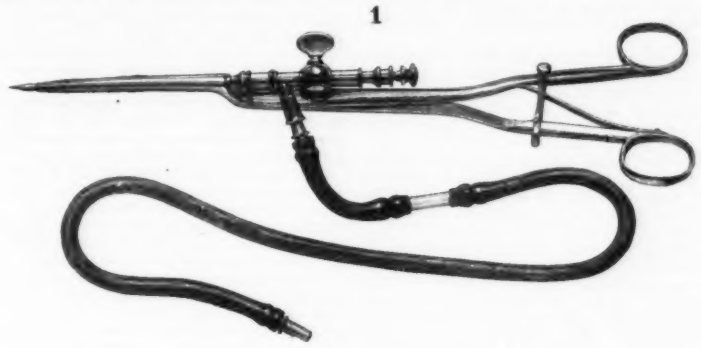
But the drops may be seen separate and may even

be shown to a large number of persons by projecting the stream upon a screen and dividing it regularly by means of a disk containing apertures, and the velocity of which is so regulated that the passage from one aperture to the other shall be exactly equal to the duration of a half oscillation of the tuning fork. This may be done approximately by blowing upon the disk and in modifying its velocity until it renders the same sound as the tuning fork. This experiment, which may be represented in many ways, necessitates the resources of a laboratory, but here is another that may be repeated without trouble, and the effect of which is striking.

A glass tube terminating in an aperture of about a third of a millimeter is adjusted to the extremity of a rubber tube; the latter having been put in communication with a water conduit, or with a vessel placed 4 or 5 meters above the orifice, a stream is produced which must be absolutely clear and free from bubbles. This stream is directed upon a rubber membrane stretched at the extremity of a tube 1 centimeter in diameter, in such a way that the stream shall be intersected by the membrane at a slight distance from the place where it is to resolve itself into drops.

Every shock communicated to the orifice precipitates a formation of drops which originate at a distance. If, now, a watch with anchor escapement be placed against the tube whence this stream of water is issuing, the stream, at first continuous at the place where the membrane is situated, will be divided at the moment of the shocks. We thus obtain a servo-motor of singular power which produces a wonderful amplification of the sound; and, if the experiment be properly regulated, the tick-tack, re-enforced by the stream and the membrane, produces a noise that might be taken for that of a hammer striking an anvil. This fine experiment of the hydraulic microphone is due to Mr. Chichester Bell, a cousin of A. Graham Bell, the inventor of the telephone. Do not our readers agree with us that it is a marvel of simplicity?

1



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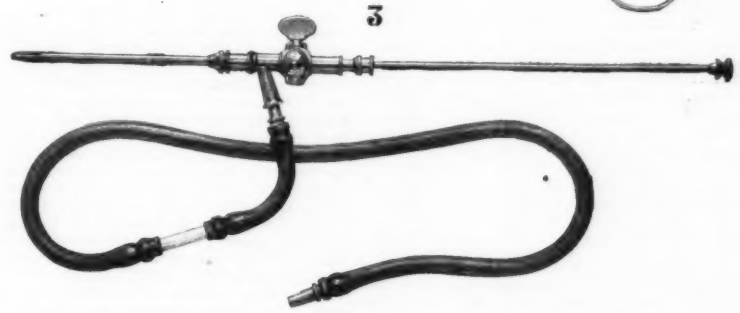

TROCAR AND DILATING CANULA FOR ABSCESS DRAINAGE.

We are now very far distant from our starting point, which our readers have perhaps forgotten. Let us recall it in a few words. All the effects of which it has been a question in this article, and all the apparatus that have been described, are based upon a judicious setting in play of a force which appears to us very insignificant—the superficial tension of water, the value of which is but 7 or 8 milligrammes per running millimeter at the surface.—*La Nature.*

TROCAR AND DILATING CANULA FOR ABSCESS DRAINAGE.

By Dr. J. JULIO HENNA, of New York.

THIS exceedingly ingenious instrument is evidently the result of close and persistent thought and affords a very promising method of treating such cases of pelvic abscess as are approachable from the natural passages. This appears to be the original object of the invention, but most probably its application will be much extended to cysts and deep-seated abscesses in various regions. The name very adequately expresses the functions of the instrument and also indicates its several parts. The greater portion of the instrument consists of an ingeniously contrived forceps which is provided with a catch lock for the purpose of preventing the handle of the instrument from being approximated and the blades opened until the necessary manipulations are complete. The blades of the forceps, when in apposition, form a slightly conical cylindrical tube which fits accurately over a trocar and canula of the siphon pattern, to which a rubber tube is attached, having a glass portion for the recognition of the presence and character of the fluid. When in use, the trocar and canula, combined with the blades of the forceps, constitute an ordinary evacuating or exploring canula with a double sheath which can be manipulated after the manner of an ordinary trocar but more advantageously, owing to the purchase afforded by the handles. After the surgeon has satisfied himself as to the position of the abscess and evacuated its contents, the aperture may be dilated very considerably with safety by unlocking the catch on the handles, and, pressing them, he devaricates the blades and can fix them at any degree of dilation by sliding backward the catch lock, which plays on a little rack situated on one of the handles. The trocar and canula having been removed, the cavity may be flushed and a drainage tube lodged in it with the greatest facility, when the forceps may then be easily withdrawn, owing to its conical outline. The component parts may be readily separated, for the purpose of cleansing them, and the handles are rendered more manageable by the introduction of an intermediate spring. By the addition of a tap to the end of the rubber tube the canula may be connected with an aspirator and the contents of the cavity withdrawn by exhaustion. The diameter of the point of the trocar is the sixteenth of an inch; the inner, complete canula fits it accurately, and the distal extremity is split into four parts that make it fit more closely to the trocar and aid in the penetration of the wall of the cavity. The blades of the forceps which form the external divided canula taper gradually from the proximal to the distal end and inclose the inner canula with great precision.

No. 8 West 40th Street.

ARE OUR DWELLINGS FIT TO LIVE IN?

By SIGISMUND BEER.

FROM daily experience we know that a person being much in the fresh air is healthier than one confined much indoors. This fact proves that the living in our houses enfeebles us, or in other words that our dwellings do not meet the requirements for healthy habitation.

In writing this article I intend first to disclose the deficiency of our dwellings in regard to health, secondly to discuss the remedy, and finally to speak of the beneficial results obtained from such improvement.

For brevity's sake I will take in view only that large class of dwellings in the city of New York which are called "private houses," supposed to be properly provided with sanitary plumbing.

Human life is based on certain conditions, primarily on respiration, by which we inhale atmospheric air, consume its oxygen and exhale carbonic acid. Atmospheric air in its natural composition and purity is therefore absolutely necessary for our breathing. Impure air or air of less oxygen for respiration must evidently disturb our system, lessen our vitality and impair our strength and health. Bearing this in mind, let us see how respiration proceeds indoors in houses as above described.

From scientific researches with the aid of exact chemical analysis, we learn that a person standing, sitting or asleep in a room inhales part of the air exhaled. We vitiate the air by our own respiration. The stagnancy of the room air is the cause of this occurrence. Its evil effect is increased while sleeping during the night, when we most need pure air and the full quantity of oxygen. It is still more disastrous during sickness, while bound in bed, especially in cases of scarlet fever or other contagious diseases where the patient is forced to inhale infectious matter exhaled and transpired.

Another prolific source for unsound respiration in our houses is the cellar air, fouled by its stagnancy. A simple way to detect its impurity consists in placing a clean earthen pot, which is glazed only inside, but is rough outside, such as is for sale in crockery stores, in the cellar. After a few weeks you will find the rough outside surface thickly covered with mould, a product of putrefaction. It is true that we do not live in the cellars, but we do live above them, where, according to the well known laws of putrefaction, the air suffers like contamination from connection.

The above may suffice here to explain why houses without proper ventilation endanger our health. That we still live in such houses is partly due to habit, partly to ignorance, but still more to indolence in regard to health, which we only esteem when lost. We endure thoughtlessly impaired development of our natural vitality, weaken our constitution, and shorten our life. We thoughtlessly impede full natural growth, strength and health of our healthy born children, and accelerate the death of those persons who are enfeebled through old age or otherwise. There is not the least reasonable ground for such a state of things. With very little extra expense we can build our dwellings with proper hygienic ventilation, by which the cellar and all parts of the house receive the air from above the roof and by which such air is continually renovated through a gentle current by means of air shafts, lined inside with tin, and having an aperture in the cellar and connecting traps in the rooms.

About ten years ago, when I superintended the construction of six dwelling houses in 133d Street between 5th and Lenox avenues, such ventilation was provided. Its immediate result was pure, bracing air in cellar and above in the houses.

More difficulty I experienced in ascertaining the sanitary effect upon the tenants, who, young and old, were always in best of health, without ascribing it to other cause but robust constitution.

It happened, however, that a family moved into one of these houses whose lady and children were very delicate and sickly. From this family I learned that for nine years during their previous dwelling in this city, in various sections, east and west and other directions, and even in the country, they had never been a day without a doctor or medicine, and that since they lived in this house and until they moved, four years later, no physician nor medicine was required, and health and strength greatly benefited. I further learned from the head of the family that he experimented, in order to ascertain the real cause of this striking improvement. Not perceiving any draught in the rooms, he threw light particles, such as pieces of tissue paper, in the air, and found that they always were carried toward the trap of the ventilator.

Another case worthy of remark here is that of a married couple of octogenarians, living eight years in another of these houses. They enjoyed during all the time admirably good health, although—and that is most significant—the lady, for the sake of convenience, hardly ever left the house, but was most of the time during the day sitting in her easy chair indoors. While in this case the ventilated habitation proves to preserve health indoors under otherwise most unfavorable conditions, the other case demonstrates its utility in curing speedily and radically certain chronic sufferings, where the aid of physicians and medicines are of no avail. The physicians cannot undo the builder's mischievous work. All they can do is to alleviate the evil. They advise us to stay aloof from our disease-breeding homestead as much as possible. They send the babies into the street, they send enfeebled adults to the country or to the mountains or over the ocean. But it is easily conceived that, benefiting as such is, its advantage can hardly stand comparison with the superior gain derived from a sojourn in a house with hygienic ventilation, where we enjoy sound respiration not alone during daytime, but also during night, and where the air is pure and free from dust and filth and noxious exhalations of the soil.

The fact alone that we have to flee from our houses to catch a sound breath shows our folly in their selection. The stupid bird in preparing its nest is wiser and more careful than we are in this respect in spite of our progress in science, art and trade, and in spite of our dream of a high civilized life. It is at least a gross mistake to imagine that we can live in an unventilated dwelling. We can only fade there. It ceases to be a mistake and is a crime when, knowing the better, we continue to do the wrong, and sacrifice thereby, not only our own health, but also the health of those who are dear to us and depend on our protection.

In conclusion, I leave it to the enlightened, intelligent reader to imagine the welfare and prosperity generations will obtain from a period of healthy habitation, and what misery and maladies would then be avoided. Unfortunately, we cannot expect such in the near future, because habit is to be overcome, and habit is inherited from generation to generation, like an eternal disease. Nevertheless, let us not despair. By enlightening the public some good will result, and to contribute to such is the object I had in view in writing the above article.

THE PHYSICAL INSENSIBILITY OF WOMEN.

By Dr. EUGENE MURRAY AARON.

COMPARATIVE ethnology, through the outgrowth of the latter half of this century, has now so many observant votaries and fully trained students that it is rapidly approaching that degree of exactness which is the theoretical goal of all sciences. To-day we of North America feel quite as well acquainted with the facial peculiarities of the Bushmen, the cranial development of the Kaffirs or the moral idiosyncrasies of the far Aleutians as were our fathers with those of the near-by American red men. But while immersed in compiling vast mountains of statistics, of measurements and other accumulations of scientific data, students in this engrossing field of inquiry have for the most part overlooked a near-by area of research which has much of interest in store for the inquirer, and which is likely to contain facts that will shed a flood of light on social and moral problems of the first magnitude. I allude to that department of comparitive ethnology which has to do with secondary sexual differentiation, with a close comparative study of such differences of nature and organization as may explain what at present are accepted as real but unaccountable peculiarities, depending, no doubt, on sex, though in a way not yet made clear. Commenting on this, a recent writer has this to say:

"Incredible as it may appear, it is, nevertheless, the

fact that no real data exist concerning the physical and moral conditions of the female constitution."

In a brief paper* Professor C. Lombroso, of Turin, has recently called attention to this lack of comparative data and has there set forth some interesting facts which have come to his attention, as well as the result of certain interesting experiments made by him. Professor Lombroso, in common with many observers in this field, has been deeply impressed with the well known fact that there is that in the female constitution which enables that sex to withstand the effects of great pain with far more fortitude than man. This has often—generally in fact—been attributed to a superior quality of mental control whereby the female system could be "keyed up," to use an expression borrowed from mechanics, to a certain required condition until the unusual strain had passed by, when the collapse that was sure to follow could expend itself in profuse weeping, and those other feminine weaknesses which go so far to compensate that sex for pain, sorrow, or anxiety. Yet is well known to physiologists, as Professor Lombroso says, that "feminine self-abandonment in moments of painful emotion is due probably to two causes: First, the fact that the female brain is known to have less control than the male brain over reflex and semi-reflex actions; and secondly, the peculiar nature of woman's early training."

When Dr. Billroth determined on making his great and celebrated experiment on the excision of the pylorus, he performed it, he tells us, originally on women, as being less sensitive and better able to resist pain. Any one who will take the pains to question a large number of dentists, as I have done, as to the comparative power to resist the necessary tortures of the operative chair shown in the two sexes, will find their testimony overwhelmingly in favor of the superior enduring powers of women. So, too, I found it in conversation with many medical men in attendance at the last series of congresses held in Washington last year.

Professor Lombroso quotes Carle, the famous surgeon, as having informed him that, in his experience, the majority of women allow themselves to be operated upon with astonishing insensibility, almost as though the body beneath the surgeon's knife was that of another and not their own. Giordano is quoted as saying that, even in the midst of the throes of childbirth, despite their apprehensions, women suffer much less than is generally supposed. Dr. Martini, a famous Italian dentist, has been surprised to observe that women undergo every variety of dental operation with much more courage and facility than men; and Dr. Mela adds that men under the dentist's hands swoon much more frequently than do women. All these observers but voice what is well known to surgeons everywhere. My own observations lead me to believe that in leper colonies the women bear the unmentionable tortures of that dread malady in its secondary stages with far greater fortitude than do the men under like conditions. So, too, I believe it to be with those kindred curses which are to be traced to the syphilitic virus.

That such a difference between the sexes as is here indicated exists no one can doubt who has given the subject any study; that its cause or causes are not understood is conceded. This is due to the very meager data yet to hand, on which to base deductions, as already pointed out. Nothing can more clearly illustrate our present insecure basis for reasoning on this subject than the recently exploded, so-called "scientific fact" that the cranial capacity of woman is inferior to that of man. That this deduction was erroneous is clearly proved by the fact that in establishing the parallel the difference in the respective weight, height, and size of men and women had not been taken into the calculation. When due allowance is made for the smaller bulk and weight of woman it is now clear that the capacity of her brain is relatively very little, if any, inferior to that of her male companion. Not alone physically, but morally a well, the nervous sensibility of woman would seem to differ from that of man. As Balzac has said in his *Cesar Birotteau*, women apprehend trouble more keenly than men, but feel it far less when it actually overtakes them. Here again the world has been content to jump to the conclusion that it is woman's superior mental control of her feelings that enables her to nerve herself for the necessary suffering when the ordeal at last reaches her. But is it not clear that, if this is the explanation, then the consequent collapse, which must necessarily follow, will contribute in a great degree to that waste of nerve tissue which leads to an early breakdown? And if this be so, ought we not then to find that woman's "reasonable expectation" in the life tables is much less than that of man? Yet, as Professor Lombroso points out, the best European and American authorities on this subject inform us that, from the ages of twenty to fifty, when most subject to mental and moral strain as well as to physical hardship, the rate of mortality is much less in woman than in man.

Thus the average of woman's life throughout Christendom is much longer than that of man, leaving out of the account the fact, in itself a suggestive one, that the number of suicides among females is far smaller than with males. Then, too, the greater physical frailty of woman and the extra element of danger which threatens her life incident to childbirth, when taken into consideration in this connection, accentuate her greater average living and strain-bearing powers to a still greater degree. Is it not clear, then, that only on what has been termed "the hypothesis of her inferior sensibility" can we explain these dual forms of aptitude for withstanding trials—physical or mental?

In reply to this it will at once be urged that woman is much more readily moved to a show of grief or to giving way to certain sorts of physical suffering. But, as has already been shown, this is mainly to be attributed to those educated faculties which the peculiarities of her early environment and home training have called into great play. The man of the world knows how easy it is for any queen of the stage, and especially for a successful member of the upper walks of the *demi-monde*, to call to her aid "the ever-ready tears."

"First laughter gay, then bitter tears
Denote the play of joys and fears,
Which have no part
Within her heart;
But are the skill of practiced years."

* *Fortnightly Review*, March, 1892.

If the worry threatening her can be avoided by entreaty, if the pain dreaded can be escaped by a show of timidity, then tears and outcries and special pleadings are always promptly at her command. But if these things must be endured, she much better than man can endure them. This is much as it is with a pig and a horse. Kick the one, and a squeal is the result; kick the other, and while no noise may follow, probably will not, the kick is quite likely to be returned with compound interest. Yet there can be no doubt that the horse will suffer far more than the pig.

Dr. Tait, at the last Congress of the French Surgical Society, 1891, spoke of the fact that even the sexual sensibility of woman is not on a par with that of man, as is also the case in the female sex of all animals so far as comparisons have been made. Says Professor Lombroso, "May it not be argued that the comparative infrequence of cases of sexual psycopathy [insanity arising from morbid sexuality] in women as compared with men tends to denote inferior sensory irritability?" This, as he also observes, may likewise account for the fact that among all peoples chastity has been regarded primarily as a female virtue, and why, at all times, and among all races, adultery should have been regarded and punished as a so much more heinous crime in woman than in man. The opinion, so prevalent among many, that it is the erroneous view taken by society of the relative positions assignable to man and woman in their moral relations which has caused the latter to stand before the world in a so much more difficult position, is, in the opinion of some best fitted to judge, very misleading. Society's view is not likely the outgrowth of man's desire and woman's weakness, as is commonly urged, but the slow, instinctive growth from the appreciation in earlier times of the marked differentiation which exists between the sexes in these sensory faculties. Though not often reduced to reason in the mind, all will be likely to appreciate the justness and accuracy of the saying of a gifted gynecologist who has used these words: "Man loves woman for her sex; woman loves in man the husband and the father." In the former, sensory acuteness is an impelling motive; in the latter, sentimental and not physical reasons hold sway.

By the use of the æsthesiometer, Professor Lombroso has thrown much light on these interesting problems. The æsthesiometer is an instrument usually made on the model of a pair of calipers, with the points somewhat rounded or knob-like. It is used to test the tactile sensibility of a person, *i. e.*, to ascertain how near together these points may be brought before they feel as one point and the dual impression that they should make is lost. It is obvious that this will afford a very fair test of the degree of sensibility to touch or contact on the skin which may exist, and either as a comparison between different parts of the body of one individual or as between different individuals of like or dissimilar races or conditions, will afford many suggestive facts. Attached to this instrument is a graduated scale, which measures the tactile sensibility in millimeters. The following table, taken from the researches of Landois and Stirling, gives a fair idea of the great diversity which exists between various areas and between an adult and a twelve-year-old male:

Area.	Adult Man.	Boy of Twelve
	Mm.	Mm.
Tip of tongue	1·1	1·1
Red part of lip	4·5	3·9
Tip of nose	6·8	4·5
Ball of thumb	6·5	...
Ball of little finger	5·5	....
Center of palm	8 to 9	....
Great toe	11·3	6·8
Back	11·3	9·0
Hard palate	13·5	11·3
Forehead	22·6	15·8
Back of hand	31·6	22·6
Knee	36·1	31·6
Gluteal region	44·6	33·8
Neck	54·1	36·1
Thigh or upper arm	67·7	31 to 40

From this table some facts are to be gleaned which have a very direct bearing on the things of everyday life. How much more the boy of twelve suffers with a corn on his great toe than does his father, the latter can better appreciate when he realizes from these measurements that the tactile relation is almost as two to one as against the boy's comfort. Again this youth of twelve would naturally prefer, by 50 per cent., that chastisement should be administered to him in the orthodox manner across the exposed gluteal region than on the back of the hand, as is now customary in some village schools. The wisdom of nature which locates a carbuncle on the back of the neck (with a tactile measurement of 54·1), rather than on the tip of the nose (tactile measurement 6·8), appeals to more than one sense of the æsthetic in this light.

To Professor Lombroso appears to belong the credit of opening up the interesting field of inquiry which is developed by the comparative use of the æsthesiometer on men and women. Of this special branch of the inquiry he has this to say:

"I have myself used Weber's æsthesiometer to measure the power of tact and sensitiveness to pain at the tip of the forefinger in over a hundred women, and I have found that, except in the case of very young girls, whose tactile sensitiveness is exceedingly developed, woman's sense of touch is, in general, nearly twice as obtuse as that of man."

From the many measurements made by him and under his direction at Turin the following averages were ascertained: Plebeian women, 2·6; superior class, 2·0 mm.; average for men only, 1·6 mm. In measurements and experiments for that special purpose he was unable to discover much difference between men and women in their senses of taste and smell; in fact, if such difference does exist, in this case it seems to be rather in woman's favor. This, however, was not the case when, with the electric algometer, his experiments were directed to the field of general sensibility. By these experiments it was clearly shown that woman is inferior to man in her sensibility to pain, and as a consequence is by that much better able to bear pain with fortitude. Among no less than fifty women of the lower class the general sensibility was represented by an average of 90 mm., and sensibility to pain by 58 mm.; while among men of the same class the figures were 94 mm. and 64 mm., respectively. In very young men he found general sensibility to be represented by 95 mm. and that of pain by 78 mm.; while the measurements for young girls were 91 and 70 mm.

That these figures are pregnant with meaning is evident; that they contain the explanation of woman's greater seeming fortitude is a fair supposition. That they are sufficiently indicative of promising results to make much deeper further research in this barely trodden field worth while to the comparative ethnologist, the surgeon, and the moral philosopher is very apparent. To Professor Lombroso belongs the credit of suggesting this subject of inquiry to students; the wonder now is that such a suggestion is necessary or even possible at this late day.

A LUMP OF SALT AND A GLASS OF WATER.*

By Prof. ROBERT B. WARDER.

THE child is born with an impulse to investigate. The light from an open window or a candle arrests his attention. He puts out his hand to take either an orange or the moon, not merely with the greed for possession, but rather with the natural appetite for inquiry. His toys are broken, not in wanton destructiveness, but with the desire to apply them to new uses and to investigate the natural philosophy of their construction. His play-time is not squandered, for both nature and art contribute to his laboratory training.

Happy is he who has opportunity to roam over broad fields, under the sympathetic guidance of such parents as my own. The barnyard is a favorite resort. In a feeding trough he discovers a hard and rounded mass, glistening in spots with vitreous luster, though mottled with rust and earthy streaks. It is a lump of rock salt; and he gains a lesson in physiology, in learning that this (as well as grass) is a needed kind of cattle food. Resting no longer for studies here, he wanders through pasture and woodland. A crystal pool oft allures him to experimental researches with floating bodies. Perhaps our young engineer goes so far as to construct a dam and race, utilizing a fraction of one per cent. of his water power in turning a wheel.

Let us now take up the story where our young people are too apt to leave it off. The boy knows that the water is hard enough to skate on in winter; that it yields to slight pressure when he takes a swim in July, —or even in January, under certain conditions; and that when he comes out dripping, the moisture will shortly disappear into the atmosphere, whence it may return once more as rain. He is familiar with salt in the first of these forms, as a solid, but has not seen it melt in the chemist's crucible, and may not know that it daily takes the gaseous form also in the pottery, under the heat of the kiln, to impart the glaze to his mother's milk crock. Both these bodies, like many others, may become either solid, liquid, or gaseous, according to the temperature. In the first, the particles of the mass adhere with considerable force; in the second, they are free to roll about among themselves, being constantly mingled together, but rest safely in an open vessel; in the third, each molecule, as if endued with life, may dart hither and thither under the law of non-restraint and escape through the smallest crevice.

A glass of water and a lump of salt; would not this dissimilar pair show some affinity if brought into each other's company? Very short distances are a bar to the love making of material things. Our anchorite from the cavern is politely introduced to the sylph of the Potomac; at once he begins to yield to her gentle persuasion. His asperities gradually disappear under her warm embrace, while she also suffers a reflex influence; a marked character pervades her whole being, so that if a single drop from the bottom of the glass were now placed upon your tongue, you could not recognize the refreshing stream of Great Falls.

Let the couple now remain in undisturbed seclusion, and the nature of each becomes transformed; try to shake them apart, and you but hasten the union. Stolid insensibility will finally yield to ceaseless pulsations; and, behold, a fluid fills the glass alone, offspring of the two parents, looking just like its mother, but the paternal influence will be recognized on closer acquaintance.

We now have two fluids side by side. With ordinary use, the powers of eye, ear, smell, and touch fail to distinguish the mother and daughter. The taste alone gives immediate evidence of the difference.

But let us examine more closely; and, first, by chemical tests. Solution of silver nitrate, added to the brine, gives a white curdy precipitate containing *chlorine;* a platinum wire would take up enough to impart a yellow color to the Bunsen flame, indicating *sodium*. These two constituents may be separately recognized in the solution by the appropriate tests, where only common salt was added.

So, in general, if we wish to detect a salt in solution, we depend upon properties belonging to the basic radical and those belonging to the acid radical, the appropriate tests being separately applied. Such properties are called "additive," since they express the sum of the properties of the constituents. The special use of this term may become clearer on reviewing some electrical properties.

Two kinds of solution are distinguished by means of the electric current. Absolutely pure water seems to be a non-conductor, while the addition of a salt, acid or base, enables the current to flow, the added body being separated into two parts called *ions*, which appear at the two electrodes. Such bodies are called electrolytes, and the quantity of electricity passing through the fluid is directly proportional to the quantity of electrolyte decomposed. Many organic bodies are not thus decomposed, their solutions being non-conductors.

While the molecule of sodium salt is believed to contain but two atoms, and sugar contains at least forty-five, yet the former may be separated by the electrical

* Presidential address before the Chemical Society of Washington, delivered January 28, 1892.

influence in a manner from which the latter is free. The forty-five atoms of the sugar molecules dwell together as a unit; while the two atoms of common salt may part company and enter into new relations, thus presenting a scene of activity and complexity which we should hardly expect from its apparent simplicity.

Let a current pass though a solution of copper sulphate, entering through a copper plate and passing out at any properly coated form, the copper is carried through the solution with the current and is deposited as an electroplate coating, while the negative radical slips back to attack the cathode.

The quantity of basic and acid radicals thus transformed under given conditions depends upon the conductivity of the solution, but to compare solutions of different kinds we should make the concentration proportional to the chemical equivalents.

Ostwald has measured the molecular conductivity of many solutions, of varying degrees of concentration. The following are a few of his results to the nearest unit; for extremely dilute solutions, $\frac{1}{1024}$ normal. The differences are shown in bold-faced type:

Li Cl	110	**9**	Na Cl	119	**23**	K Cl	142
		5			**6**		
$Li NO_3$	105	**9**	$Na NO_3$	114	**22**	$K NO_3$	136
		8			**7**		
$Li ClO_3$	97	**10**	$Na ClO_3$	107	**23**	$K ClO_3$	130

The numbers obtained for lithium salts are about 9 less than for the corresponding sodium salts, and these about 23 less than for the potassium salts. Comparing the horizontal lines, we find the numbers for chlorides about 5 higher than for nitrates, and these about 7 higher than for chlorates.

To appreciate the full meaning of these differences in the numbers, we may again refer to the tests of qualitative analysis. A salt has no single property by which it is recognized, but we depend upon the several properties of basic and acid radicals, which are largely independent of each other.

The molecular electrical conductivity is here expressed merely by a number; but do not be repelled by a sense of vagueness. This number expresses motion; the greater the number the more activity displayed in transfer of electricity. The lithium atom is less active in this way than sodium, the sodium less active than potassium; and this is true whatever be the company in which the metal is found. The activity of chlorine is greater than that of the nitric radical, and this greater than the chloric radical; but the activity of the salt must be viewed as the sum of this property for the components. Each number is clearly the sum of two numbers, one belonging to the basic, the other to the acid radical. On no other hypothesis can we explain the fact that when we select two basic or two acid radicals, the substitution of one radical for the other always results in the same change of the number, no matter what third radical may be combined with these two. In a word, the molecular electrical conductivity is an additive property of salt solutions. Other additive properties are found in the field of optics.

One summer day, as I sat in a row boat, upon a clear Wisconsin lake, admiring the delicate forms of vegetation below me, that which was really four feet under the water appeared to be but three. The rays of light from below were so bent downward in passing out of the water that the whole bottom seemed lifted up. But chemist and physicist are on no holiday excursion. Not content with a superficial enjoyment of wonders, we must carefully measure the index of refraction, reason upon the results, and compute them in such form as to be available in discovering nature's laws. The refraction equivalent for sodium salts is about 3·4 more than for the corresponding salts of potassium. Iodides are about 10 units higher than the corresponding bromides. The constant differences show that this property also is "additive." We might assume refraction equivalent for each basic and acid radical and add the corresponding terms to obtain the equivalents for the various salts.

Again, polarized light passes through a sirup and the plane is rotated through a certain angle. The "molecular rotation" has been measured for many different organic salts and ethers with very striking results; the salts frequently exhibit rotation as an additive property, while the others do not conform to this law. The English chemist, Perkin, has greatly extended this line of investigation by using a magnetic field. The solution of an optically inactive body (as inorganic acids and salts) is placed within a helix and the plane of polarization is then rotated by an electric current. The difference in behavior of electrolytes and non-conductors is thus confirmed.

Taking up a glass of water, I note that the surface is not a plane, but the fluid is drawn up where it meets the glass. The brine seems to behave in the same way; the eye detects no difference in the curve formed by brine or pure water. We must find some way to measure this property by drawing the walls of the vessel closer together. Inserting a very narrow tube, the liquid is seen to rise to a certain measurable height. This is called capillary action and is referred to surface tension. In a tube of given size a greater weight of brine is thus supported than of pure water. The study of these differences in capillary action yields valuable testimony that need not detain us at present.

The flow of an ideal liquid from a small opening under given pressure may be calculated by the theory of hydrodynamics. But experiment indicates a *diminished* flow varying with the several solutions. This may be explained by the *internal friction*, another occult property, requiring the refinements of both experimental and theoretical investigation.

If we measure out equal volumes of water and brine, we find the latter has the greater weight; when salt is added to water, the whole volume of the brine is greater than that of the water alone, but less than that of the water and dry salt added together.

The volume of each, however, depends in part upon temperature. Conceive two thermometers, filled with water and brine respectively instead of mercury or alcohol, with bulbs and tubes of the same size; the scale, from zero to 100° C., would not be divided into precisely equal parts to represent degrees, for water expands more rapidly at higher than at lower temperatures. The space from 0° to 10° is less than that from 10° to 20°, and so on throughout the scale. In brine, the fluid expands more uniformly, and the intervals would be more nearly equal. De Heen finds that the expansion becomes more uniform as the solution is more concentrated. At 55° all solutions of common salt expand nearly as pure water. The same is true for other salts at other temperatures.

Another phase of the same truth was noted long before by Kremers. While the long columns of numerical values may be very forbidding to the average reader, it is only by the twofold task of accumulating and digesting such data that the rich prizes still in store can be secured.

The volume of a solution may also be changed without altering the temperature. Water can be slightly compressed by a great force. The addition of 5 per cent. of salt alters this property, so that the compressibility is now about one-tenth less than that of pure water. Many salts have been investigated by Rontgen and Schneider in respect to their compressibility, which is shown to be an "additive" property.

If we leave water and brine in the cold, both will freeze; but the water usually begins to separate as ice first, thus making the brine more concentrated. If we test both fluids with a thermometer, we find that the brine must be cooled to a lower temperature before freezing begins. The *differences* between freezing point for solutions and the solvent have been made the subject of many extended researches with special forms of thermometer. Readings are estimated to 0·01°. The result has been a flood of light upon the molecular weights of substances in liquid form, together with some remarkable differences between salt and sugar, between brine and sirup, or between the two classes of solutions which these represent.

The barometer contains a column of mercury just high enough to balance the atmospheric pressure. Let us take three similar barometers, introduce a drop of water into the Torricellian vacuum of the first, and the mercury falls; the water is partly changed to vapor, which exerts a certain *pressure* on the mercury, and this vapor pressure may be measured by the difference in level.

Now put a drop of brine into the second barometer; the mercury falls here also, but to a less extent. The vapor pressure of the brine is less than that of pure water. Either there is a greater striving among the molecules of pure water to fly away in the gaseous form, or the salt exerts some restraining influence, holding the water back. In this experiment we soon reach equilibrium; it is a statical method, but vapor pressure is also manifest in the commonplace operation of drying clothes from the wash. Think of the process which takes place (with varying speed) either in the heat or cold, in the wind or in shelter; and dynamical problems are brought to view. The process of evaporation or condensation in a current of air affords another means of determining the relative vapor pressure of various solutions.

If we now boil water and brine in separate vessels, we not only have evaporation from the surface, but bubbles of vapor are formed in the mass and burst upward through the liquid. At this stage we say that this pressure of vapor equals that of the atmosphere; but when this point is reached, the brine is hotter than the water, the boiling point of the former is the higher. Thus we have a third method of comparing vapor pressures. This property of solutions, in its quantitative aspect, rivals the freezing point as an avenue to the secrets belonging to our subject; which are yet only partly disclosed.

Although the lump of salt will sink in water, being much heavier, yet as solution proceeds the denser brine gradually mixes with the water above, until at last the whole fluid would be practically uniform. Various salts will diffuse at different rates. A porous membrane will transmit the molecules of water more readily than those of a salt. For certain theoretical investigations we may conceive a "half permeable" wall, with openings so small that the water alone can penetrate. As a filter separates a solution from the insoluble residue, so the half permeable wall is to transmit the solvent while preventing the passage of the dissolved salt. No material has been found fully possessing this ideal property; but theoretical deductions have already been confirmed by experiments with clay cells, the pores being partly closed with a film of insoluble precipitate. If a solution fills such a cell while fresh water surrounds it, the contents soon show a considerable pressure, which is measured by a manometer. This phenomenon is called "osmotic pressure," and we may have several conceptions of its cause. Either there is attraction between the unlike molecules in the brine and the fresh water, so that the latter flock in where the salt is imprisoned (as ducks fly to the decoy) until the internal pressure arrests the flow; or the osmotic pressure may be due to the aggregate force of impact of the many moving molecules. The latter is the view generally taken.

The several properties that have just been considered require numerical expression; but these numbers are wonderfully related to each other and to the doctrine of the conservation of energy. For example, consider the relation of osmotic pressure to vapor pressure. Let a cell with half permeable wall, connected with a vertical tube, be filled with solution and immersed in a tank of pure water, the whole arrangement being placed under a bell jar in vacuum.*

Under osmotic pressure, the solvent will enter the cell until a certain pressure is reached, as determined by the height of the liquid in the vertical tube. Evaporation will take place at the same time, both from the surface of the solution in the tube and from the solvent in the tank, at their respective levels, until the jar is filled with vapor. A condition of equilibrium will eventually be reached, for otherwise we should have perpetual motion. On the half permeable walls of the porous cell we have an inward and an outward pressure, whose difference is measured by the height and density of the solution in the vertical tube. On the surface of each fluid we have a vapor pressure, the difference being measured by the same height and the density of the vapor in the bell jar. The former difference is the osmotic pressure, the latter is the diminution of vapor tension, caused by adding the solid to the solvent; and these two values stand exactly in the ratio of the densities of solution and vapor. By other thermodynamical considerations, a relation is traced between osmotic pressure and the change in freezing point, electrical conductivity, etc.

The astronomer who wishes to learn the distance of the sun with the greatest precision, depends not upon parallax nor upon the transits of Venus alone. Aberration of light, the eclipses of Jupiter's moons, direct determinations of velocity of light upon the earth, and other related quantities are duly harnessed together in appropriate equations, and subjected to the test of least squares. So he who would thoroughly investigate the subject of osmotic pressure, with all its tremendous consequences, both theoretical and practical, must leave no stone unturned, but must bring all the facts into harmonious array for a fresh attack upon the secrets of a lump of salt in a glass of water.

Important analogies between the physical properties of gases and those of dissolved bodies are pointed out by van't Hoff.* The laws of Boyle, of Gay-Lussac, and of Avogadro, all have their counterparts in the phenomena of osmotic pressure.

First.—Boyle's law says that the pressure of a gas is inversely proportional to its volume—that is, that as the quantity of any gas in a given volume is increased or diminished, the pressure changes in the same ratio; so the osmotic pressure of many solutions is found to vary directly as the concentration.

Second.—Gay-Lussac's law may be expressed by stating that the gaseous pressure varies directly as the absolute temperature. The same is true of osmotic pressure.

Third.—Avogadro's law implies that two gases at the same temperature will have *equal* pressures when the masses of equal volumes are proportional to the molecular weights. The same is true for osmotic pressures in equivalent solutions of different comparable substances.

To calculate the osmotic pressure, conceive the solvent to be absent while the solid occupies the same space, as a gas. The hypothetical gaseous pressure as determined by the three fundamental laws is then equal to the osmotic pressure required. Conversely, to determine the molecular weight of a dissolved body, we may find the osmotic pressure, and calculate as for a gas; practically, the depression of freezing point is the physical property usually measured.

In a word, the three fundamental laws of gaseous matter are found to be true of dissolved matter, simply by substituting osmotic pressure for gaseous pressure, while even the anomalies and limitations so long recognized in gases and vapors find their counterparts in solutions. Can we find identity of cause where there is almost identity of result? In a gas, matter is in a far more dilute condition than in ordinary solids or liquids; the intermolecular spaces are evidently far greater than the space occupied by the molecules themselves. The same is true in a dilute solution of salt; only here the intermolecular space is largely occupied by the water. In both cases motion is indicated by the phenomenon of diffusion; in both cases each moving molecule is endowed with kinetic energy, and the sum of the *vis viva* of all the molecules exactly accounts for the laws of pressure. The formulas used to unfold the kinetic theory of gases may be applied without change to a kinetic theory of solutions. In a jar of hydrogen the molecule darts hither and thither at the rate of a mile a second, asking for no support save other molecules from which it rebounds. If the hydrogen is mixed with the denser vapors of paraffin, it will still exert its own pressure upon the walls of the vessel as though it were alone. Our salt is less ethereal; the molecules are heavier; they move more sluggishly. Very slowly do they rise, as though climbing with painful effort upon an unsteady ladder of water molecules; yet, with the aid of the half permeable wall their pressure is found to be just what it should be on the kinetic theory if the salt alone occupied the space as a gas in the absence of water.

Anomalies and limitations have already been mentioned. There is no "perfect" gas, none that exactly fulfills the fundamental laws, for these would imply two conditions which are only approximately true.

First, we must assume the size of each molecule is so small that it counts for nothing in comparison with the spaces between the molecules; and, second, the molecules are so remote from each other that their mutual attractions vanish. Both of these conditions are most nearly realized as the gas is most rarefied, either by increasing the temperature or by diminishing the pressure; so with solutions the ideal conditions are most nearly fulfilled as the solutions are most dilute. Hydrogen, which most nearly agrees with the "ideal gas" in its properties, is not compressed to one-tenth its volume by tenfold pressure, but occupies a little more than one-tenth volume. Here the molecules themselves may be considered as incompressible bodies, occupying too great a fraction of the whole space to be left entirely out of account. A modification of Boyle's law assumes that the total intermolecular space varies inversely as the pressure. In most gases and vapors, however, the deviation is in the opposite direction. As the molecules approach each other their attraction makes the volume *less* than required by Boyle's law. The piston of a Corliss engine, which glides so beautifully to and fro, in obedience to valve and governor, is impelled by the bombardment from an array of vapor molecules, each one following its own impulse, almost untrammeled, in the go as you please contest; yet some mutual attraction is manifest, for the steam exerts a little less pressure upon the piston than would an ideal gas under like conditions; so osmotic pressure, instead of increasing directly as the concentration, may increase a little less rapidly.

There is a well known body whose vapor density has long been recognized as abnormal. Ammonium chloride when converted into vapor is found to occupy twice the volume predicted by theory. In other words, a given volume of the vapor exerts twice the theoretical pressure. The explanation is easy when we learn that the salt is dissociated into the two gases, ammonia and hydrochloric acid. Nitric oxide has a density at lower temperatures nearly corresponding to the formula N_2O_4; at about 150° C. it is NO_2; and the gradual processes of dissociation with increased temperature may be traced by the vapor density.

Similar anomalies in osmotic pressure may lead to a similar interpretation, although quite antagonistic to our ordinary conception and teaching. Sodium will

* A figure, with fuller explanation, will be found in Ostwald's "Solutions," p. 184. This work has been of great service in preparing the present paper.

* *Zeit. Phys. Chem.* 1, 481-508 (1887).

burn in chlorine with striking evolution of light and heat, we recognize the product as a new substance. Chemical action has taken place. By a large expenditure of energy, the elements may again be separated. Thus also is chemical action. But we dissolve the salt in water, evaporate, recover it as before, and are prone to count all these changes as purely physical. Little do we suspect that the dilute solution contains in free state the two substances which we usually know as metal and gas, the two kinds of atoms moving independently of each other, so long as they are distributed in equal numbers in any portion of the fluid. Yet such is the theory of Arrhenius, now fast gaining ground. Cold water decomposes a most stable compound, the elements being gradually reunited in evaporation and crystallization. Accept this hypothesis for electrolytes, and their peculiar properties are explained, their additive character must follow as a necessary consequence of their nature, and the several kinds of anomalies fall into harmonious relations.

On this hypothesis, the speed of chemical change should no longer be proportioned to the whole quantity of each active substance present, but rather in proportion to that part which has already suffered loosening of the bonds. The facts of dynamical chemistry afford an independent and valuable confirmation of the new views.

About thirty-five years ago, Clausius suggested, in explanation of electrolysis, that the salt is dissociated into its *ions*, the metal being torn apart from the non-metallic elements, each ion having its own independent motion in the fluid.* This theory was more fully developed by Arrhenius in 1887.† Each molecule of the fluid may contribute to the pressure, in virtue of its impact upon the walls. If a body is dissolved, the increase in number of impacts results in greater pressure, and this increase is known as osmotic pressure; but if the molecule of a salt is divided into two or more parts, each largely independent of the other, there is a further increase of impacts and of resulting pressure; there is also a further diminution of vapor pressure, a further depression of the freezing point, and further change in all other physical or chemical values which depend upon osmotic pressure. We have, then, several methods of estimating the number of parts into which a given number of molecules has separated, or of calculating how many molecules out of a hundred have been dissociated. In non-conductors, the several physical properties indicate unbroken molecules; in dilute solutions of strong bases, acids, or resulting salts, the complete molecules are the exception. This theory involves two important differences from ordinary chemical dissociation. Ammonium chloride, when heated, easily yields two well known gases, ammonia and hydrochloric acid, which may be recognized by their usual properties; but when common salt is dissolved we believe that it separates into the metal sodium and non-metal chlorine. By analogy, ammonium chloride would yield the hypothetical metal, ammonium, and free chlorine; thus each salt, acid or base is assumed to break into the basic and acid radicals or ions; hence the term "ionization" is used to indicate this form of dissociation. When ammonium chloride is dissociated by heat the two gases may be separated from each other by diffusion, so far as to be recognized separately by litmus; but when a salt undergoes ionization the ions remain in equivalent proportions in each drop of the solvent, unless great energy is expended, as by the electric current.

I have alluded to the consequences, both theoretical and practical, arising from osmotic pressure. The former have been discussed in the analogy of dilute solutions and gases, the recent methods of ascertaining molecular weights, and the process of dissociation and reunion in the additions and withdrawal of the solvent. Does this subject affect our personal comfort also, our life or safety? A few hints in this direction will close this address. A willing mistress scatters sugar over the strawberries an hour before tea time, if the family prefer the juice withdrawn; for the moment a crystal begins to dissolve upon the delicate membrane, osmotic action carries the more dilute solution to the surface; but if the fruit is thus sugared in the evening, and preserved the next morning, each berry will be shrunken and the cans will be almost half full of sirup. The oyster dealer knows nothing of osmotic theories, but has acquired the art of "fattening" by merely adding more juice to the juicy bivalve.

Osmotic action pervades the whole realm of biology. Delicate cells from leaves of the "Wandering Jew" have afforded De Vries a most beautiful method of comparing the osmotic character of different solutions, whose concentration is adjusted to conform with that of the protoplasm within the cell walls; and shall we ignore the wonderful adjustments between solution and membrane, as the sap ascends for the annual miracle of opening bud and expanding leaf? The blood globule is a minute structure; yet how much do we owe to its healthful condition! so delicate that a change in the saline constituents of the serum may shrivel or burst it. May not osmotic pressure in such tissues explain the intense suffering caused by want of salt in the diet of certain Dutch prisoners? And shall a lazy man hereafter ever have cause to complain if told that he is not worth the salt he eats?

ALBUMEN IN URINE.

SPIEGLER gives a very delicate test, which consists in floating the urine acidified with a little concentrated acetic acid upon the surface of a solution of mercuric chloride 8, tartaric acid 4, sugar 20, and water 200. This is done with a pipette, so that the liquids do not mix. If albumen is present, a distinct white ring is formed at the line of contact. By this test one part of albumen in 150,000 can be at once detected, and with a solution of 1 in 225,000 a distinctly visible ring is produced after the lapse of a minute. One great advantage of this test is that there is no necessity for troublesome operations to make the urine clear. If a precipitate is produced by the addition of acetic acid, it may be necessary to filter. Urine containing peptone does not give the reaction, but that containing propeptone does. The addition of sugar to the test solution is for the purpose of increasing the specific gravity to 1·06, and thus reducing the tendency to mix with the urine lying above it.—*Berichte*, xxv., 375.

* Pogg. Ann., 101, 347 (1857).

† Zeit. Phys. Chem., 1, 631-648 (1887).

COMPOSITION OF STARCH.

HERREN C. SCHEIBLER and H. Mittelmeier (*Ber. Deutsch. Chem. Gesellsch.*, vol. xxiii.) recur to the older view that starch is a mixture of two isomeric substances—granulose and starch cellulose, of which the former constitutes by far the largest proportion of the grains, so that nearly all the reactions usually assigned to starch are, in fact, those of granulose. It is readily transformed into soluble products by ferments and acids, which is not the case with starch cellulose. These writers classify the soluble carbohydrates into two principal groups, simple sugars and compound sugars; the latter, including maltose, milk sugar, and cane sugar, being formed by combinations of the former with loss of water, according to the formula $n(C_6H_{12}O_6) - (n-1)H_2O$. The so-called dextrin of commerce still contains sugar, from which it can be freed by precipitating three times by alcohol. Pure dextrin is still not an autonomous substance, but belongs to the class of carbohydrates which contain a free carbonyl.

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